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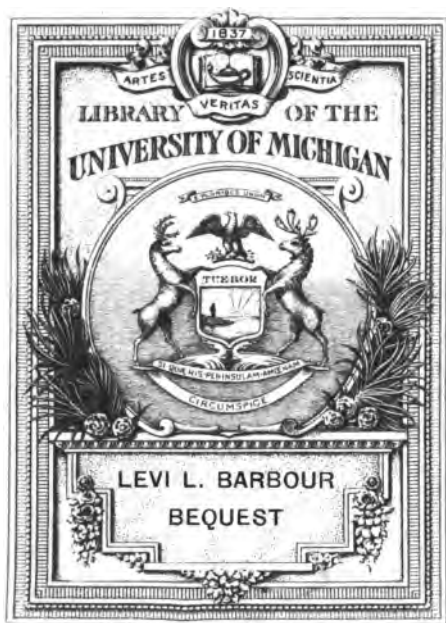
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THE CAVE-MAN. (From recent finds at Aix-la-Chapelle, France.)

THE SCIENCE - HISTORY OF THE UNIVERSE

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IN TEN VOLUMES

THE CURRENT LITERATURE PUBLISHING COMPANY
NEW YORK

1909

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THE SCIENCE - HISTORY OF THE UNIVERSE

VOLUME VII

ANTHROPOLOGY
By FRANCIS ROLT - WHEELER

MEDICINE
By DR. THEODORE H. ALLEN

INTRODUCTION
By PROFESSOR FREDERICK STARR
UNIVERSITY OF CHICAGO

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INTRODUCTION

No ~~OTHER~~ science deals with a field so ill defined as Anthropology, no other studies so varied and differing material. The scope and the content of the science are alike matters of dispute. By derivation the word of course means a discourse or treatise regarding man. It has been defined as that branch of science which studies man in the same way as geology investigates the earth or as botany investigates plant life. The motto of the Department of Anthropology in the World's Columbian Exposition was "Man and his works." It is evident that any science which studies man and his works has a limitless field. Anthropology depends upon the whole range of other sciences. It has a dozen connections with Astronomy; it is closely related with Geology; it assumes an enormous knowledge of Biology; to a great degree it includes Anatomy, Physiology, Psychology; it uses the methods of Mathematics; it is intertwined with History; Linguistics and Philology yield a notable contribution to its store. Is it possible to mark out a definite field for its investigation and to group and classify its materials? More and more its students feel that it has its definite field, its legitimate subdivisions and its special methods of investigation. Roughly we may divide the materials of Anthropology under the four subdivisions of Somatology, Ethnology, Ethnography and Culture History. Under the latter we must rank Prehistoric Archeology, perhaps the most popular subdivision of the field.

Somatology, or Physical Anthropology, deals with man

as a living being. In reality it treats of two quite different matters: First, it investigates man's place in nature; it locates him in his proper place in the scale of animal life; it considers the question of his origin; it discusses his relation to the anthropoids and other simian forms; it aims to trace his family-tree back to a primal trunk. Second, it considers man in himself as an organism. It necessarily includes the fundamental facts of anatomy, physiology and psychology. It lays the foundation for Ethnology. Ethnology is the philosophical study of human races. If we recognise—and the distinction is a good one—the difference between 'logy' and 'graphy' sciences, we shall clearly understand its scope. From the materials supplied by Somatology it aims to define the types of man. Such types are based primarily upon physical characters. Color, character of hair, head-form, stature, the form and character of facial features, variations in proportion—these and other characters are studied and combinations of them found existing among groups of human beings are built up into race types. Having defined the different types of man now existing, the ethnologist deals with such questions as the cause and extent of variation and the history of these types through the past. He is interested in the great problems of migration, acclimation, miscegenation and the like. Ethnography, as its name indicates, is a descriptive science. It bears the same relation to Ethnology that Geography bears to Geology. It is the least philosophical, the least important, but the most popularly interesting of the sub-fields of Anthropology. A general ethnography would be a complete description of the life and habits, thoughts and condition of each and every population on the globe. The special ethnography of any people is the detailed description of its entire life. Culture History deals with the same materials as Ethnography, but in a different manner. From the data furnished by the ethnographer, dissociated from the peoples, it aims to trace the progress of culture from the rudest savagery

to the highest civilization; it aims to follow the evolution of ideas; it studies the beginnings and development of institutions; it is the highest product of anthropological study.

Such is the field of Anthropology, such are its most generally recognised divisions. The tendency of students is to devote themselves to one or another of these four great subdivisions. Thus practical workers are likely to be Somatologists, Ethnologists, Ethnographers, students of Culture History, Archeologists. While this is true, the propriety of a general term which shall include them all is more and more emphatically recognised.

The fact that man is himself the subject of study has made the progress of the science exceptionally difficult. Prejudice has entered into the discussion of the great problems of the science as it has not done in such subjects as Astronomy and Mathematics, Geology and Zoölogy. This is well shown in the great question of the unity of mankind. The battle between the monogenist and the polygenist has been a bitter one; views have fluctuated; religious and political ideas and theories have tinged discussion. Monogenism was good religion in the early part of the nineteenth century. With the promulgation of Darwinism many theologians were thrown into the camp of the polygenists as their only escape from the hated revolutionary evolutionary doctrine. A whole school of American polygenists came into existence at the time of heated discussion regarding slavery. To-day the long-mooted question has little significance. Since evolution has been established and is assumed as a working hypothesis in every science, the question whether man is one or several species is simply the question as to how far back we will draw the line across the divergent branches of the human kind.

The question of man's antiquity has been the cause of many a battle. A quarter of a century of heated discussion was necessary before the claim of Boucher de Perthes

that man existed before present geological conditions was accepted. In 1859 man's antiquity was admitted as far back as the glacial period. When De Mortillet wrote his masterly manual of Prehistoric Archeology claims of greater antiquity were before the public. In one and another locality objects had been found which were believed to demonstrate man's existence in the Tertiary. De Mortillet examined the whole material. Rejecting far the greater part, he believed that enough remained to warrant the assumption that an intelligent being, a tool-user, existed in that geological division of time. When he presented his views, few were ready to accept them. To-day the whole matter has been revived and one of the most bitter discussions of the moment is being waged over the so-called "Eoliths." The crude tools for which Boucher de Perthes contended are finely finished works of art compared with the rude flakes over which the present argument is being conducted. The paleolithic relics are intentionally shaped; the eolith is simply a natural flake or splinter which shows evidence of use. The representative of the eolith argument to-day is Professor Rutot, of Belgium. His claim is distinctly that an eolith is a flake or splinter of flint, produced by natural causes, which has been used by an intelligent being for pounding, scraping, rasping, cutting or sawing. Such objects have now been found by thousands in France and Belgium, Germany and England. In age they range from the early Quaternary (or Glacial Period) back to the middle Tertiary. Against a storm of opposition and argument Rutot presents a masterly argument in favor of their authenticity. Whether these eoliths are to be attributed to man or to some other intelligent being awaits the fortunate find of remains as yet undiscovered.

It is a common assumption that primitive man was unsophisticated, a being endowed with possibilities, a creature of undeveloped talents. This assumption has been almost universal in all studies of culture history. A little thought

clearly demonstrates that such a being never can have existed. Assuming man's animal ancestry, we are driven to believe that many things which are ordinarily considered as being human must have arisen in a prehuman, brute condition. It is certain that the ancestor of man must have been a social species. Is it not quite as certain that before he had developed into anything which could be considered human certain fundamental facts of social life must have existed? The simplest ideas of rights and duties, of personal property, of friendship and hostility, of the use of nature-supplied implements, of communication, perhaps of animism—raw stuff of religion—may well have been developed by the brute, non-human ancestor. In other words, the being whom we call primitive man had already a respectable capital. This point of view renders all serious study of animal psychology particularly interesting to the anthropologist. Such books as Groos' 'Play of Animals' and 'Play of Men' are most suggestive. There is as yet practically nothing that can be called a study of the psychology of anthropoid apes. Such a study would be of interest and significance. Not that it is assumed that any one of the existing anthropoids is ancestral to humanity. They are our cousins, not our progenitors. A correct picture of their mental operations would not be that of our precursor, but they and we have inherited from the same ancestry.

Ethnographers to-day divide into hostile camps upon the question of the significance of similarities in culture in widely separated areas. When one finds a striking detail or feature of custom or belief in populations widely separated, the immediate and natural assumption has always been that this similarity indicated relationship or contact in the past. The assumption is a dangerous one and has been so frequently and rashly made as to bring contempt upon the method. It is so easy in finding a few simple customs among the American Indians which resemble the practices of the old Jews to assume that the

Indians are the "Ten Lost Tribes of Israel"! A revolt upon the part of thoughtful students against such loose and careless comparison and assumption was natural. There is no question that this revolt has been carried to a ridiculous extreme. It finds its fullest development in Daniel G. Brinton, through years the leader in American Ethnology. For Dr. Brinton and the great school of Ethnologists of which he was a spokesman, simialrities in culture do not necessarily show relationship, or contact, or evidence of migration, but simply demonstrate the psychical unity of mankind. His thesis was that everywhere the human mind subjected to similar conditions would strike out similar results. The same thought, the same belief, the same practice, the same art and industry might originate independently in two or many different sections of the globe. The argument is interesting and valuable, but may become misleading. Every one admits the psychic uniformity of man. But, for most students, close and peculiar similarities of the details in stories, in games, in religious practices, in complicated mechanical devices suggest actual contact in the past. No such contact should be carelessly assumed, every case should be rigidly investigated; but the true ethnographer must weigh with care all such likenesses.

Major Powell divided the field of Culture History into five divisions. These he called Esthetology, Technology, Sociology, Philology and Sophiology. Art, Industry, Society, Language and Belief are the five expressions of the human mind. Each is ample to fully occupy many students for an indefinite period in the future. Each will yield its harvest. Into each the student must carry the methods of rigid scientific study. When one realizes the enormous scope of any one of these and then appreciates its proper place as a small section in Culture History, itself but one of the four great subdivisions of Anthropology, he begins to realize the magnitude of the scope and content of this important study.

FREDERICK STARR.

ANTHROPOLOGY

CHAPTER I

MAN'S PLACE IN NATURE

DESPITE what philosophers may say, Man to himself will always be the center of the universe. It may be possible that beings superior to Man even now do exist, tho unrecognised by human sense, in the same manner that Man cannot be understood by the minute corpuscles in his blood. But such a thought is so strange to the common viewpoint that it seems almost fantastic, and Man's Place in Nature, he firmly believes, is at the top, while the only idea which has reconciled him to his manifest ancestry in the lower orders of life is that the scale of evolution points to him as the highest form yet attained.

Wherefore Anthropology, including as it does the entire past of Man, can scarcely be regarded as a single science, and the anthropologist is conscious of a certain vagueness as to the scope of his labors. Since Man in a sense sums up all that has gone before, all is included in him, and since his present position cannot rightly be understood without reference to that which has gone before, it becomes evident that a large group of arts and sciences which appear mutually diverse find an interdependence in him. The old saying, "I am a Man, and therefore nothing human is foreign to me," fairly expresses the ground upon which the anthropological sciences claim attention.

The links of Anthropology to the other sciences are

numerous and close. Thus there is what in France is called pure anthropology or anthropology proper, but which is better called physical anthropology—the science of the physical characters of man, including anthropometry and craniology, and mainly based upon anatomy and physiology. There is comparative anthropology, which deals with the zoölogical position of mankind. There is prehistoric archeology, which covers a wide range of inquiry into man's early works, and has to seek the aid of the geologist and the metallurgist. There is psychology, which comprehends the whole operations of his mental faculties. There is linguistics, which traces the history of human language. There is folk-lore, which investigates man's traditions, customs and beliefs. There are ethnography, which describes the races of mankind, and ethnology, which differentiates between them, both closely connected with geographical science. There is sociology, which applies the learning accumulated in all the other branches of anthropology to man's relation to his fellows and requires the coöperation of the statistician and the economist; and each and every one of these is an immense subject, while nothing has been said of the manner in which all human æstheticism traces its spring to prehistoric times.

Also there is another side to the question. Great as is the diversity of the anthropological sciences, their unity is still more remarkable. The student of man must study the whole man. No true knowledge of any human group, any more than of a human individual, is obtained by observation of physical characters alone. Modes of thought, language, arts and history must also be investigated. This simultaneous investigation involves in each case the same logical methods and processes. It will in general be attended with the same results. If it be true that the order of the universe is expressed in continuity and not in cataclysm, the same slow but sure progress must be evident in each branch of the inquiry. Thus nothing is lost, no race is absolutely destroyed, everything that has been still

exists in a modified form and contributes some of its elements to that which is.

There is yet a deeper sense of study which traces back the very roots of thought, for it would be as idle to study the human body alone without reference to that of any other creature and attempt in that way to decipher its genesis, development and meaning as to attempt to comprehend a single human mind without including in the examination not only other human minds in all stages of evolution, but equally all other minds to which that of Man is related.

The debt is never to be forgotten that is owed to all minds other than human, "belonging," as Sir Daniel Wilson once said before the American Association for the Advancement of Science, "belonging to our kinsfolk, the animals, minds which stand to-day like mileposts along the almost infinite length of the path which our mind has followed in its upward march across the immensities and eternities from its remote infancy to the present hour; minds which in a thousand faculties represent to us everywhere, in infinite sameness and variety, replicas of our own or of parts of our own, showing us, as the poet says, tokens of ourselves which we 'negligently dropped as we passed that way huge times ago.'"

"As man's bodily life rests upon and grows from that of countless prehuman ancestors," says Dr. R. M. Bucks, "as man includes in his structure the heart of the reptile, the gills of the fish, as well as the forms in outline of innumerable still lower races, so is his so-called human mind rooted in the senses and instincts of all his ancestral species; and not only so, but these senses and instincts still live in him, making up, indeed, far the larger part of this current everyday life; while his higher psychical life is merely the outgrowth and flower of them.

"As truly as the plant is an embodiment of inorganic matter vivified by the transmuted forces which in the non-vital world about us we call light and heat, so truly is

man's mind the outcome of—the expansion and culmination of—the imperfect sensation of the worm, the rudimentary sight, hearing and taste of the fish and reptile; and the simple consciousness which, springing from these, passed to us after almost infinite ages of slow evolution and amelioration through tens of thousands of generations of placental mammals, our immediate progenitors.”

In the growth of mind, whether that of the race or of an individual, two distinct processes are observed: First, the very gradual evolution to, or toward, perfection of faculties that have already come into existence; and, secondly, the springing into existence of faculties which had previously no existence. For it is clear that no faculty came into mature and perfect life at once. Hearing and sight developed by slow degrees from the sense of touch, and in the region of the intellect conceptual life was born from ages of receptual and that from millenniums of perceptual.

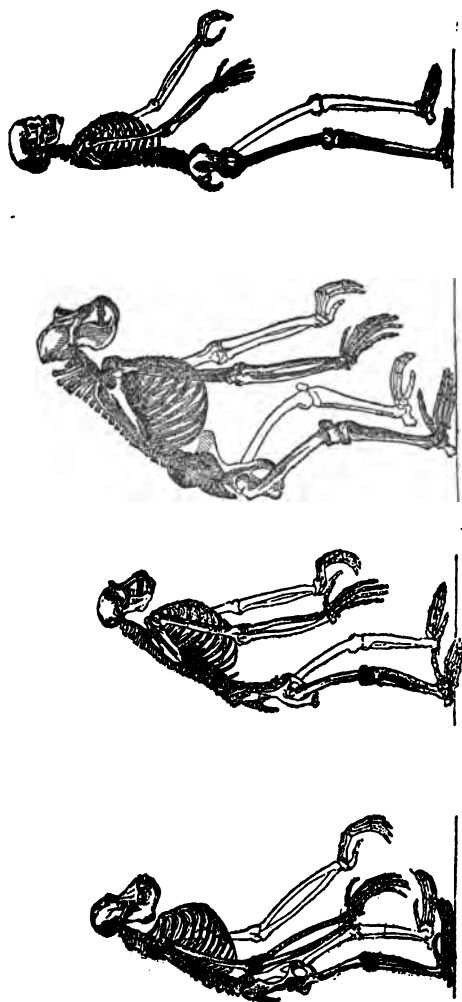
Now let mind be supposed growing for countless years in the way set forth. It begins as mere excitability; to that after a long time is added what may be called discrimination, or choice and rejection of, for instance, different kinds of food. After another long interval of almost infinitely slow advance sensation appears, and with it the capacity of pleasure and of pain; then, later still, memory; by and by recognition of offspring; and successively thereafter arise reason, recognition of individuals and communication of ideas. Concurrently with these intellectual faculties certain moral functions, such as fear, surprise, jealousy, anger, affection, play, sympathy, emulation, pride, resentment, grief, hate, revenge, shame, remorse and a sense of the ludicrous, have also arisen in the nascent mind. This is the mental plane of the higher animals, which is equally that of the human being at about two years of age. Then occurs in the child the mental expansion which separates man from the higher mammals—for something like a year the child mind steadily grows from the status of the latter to the status of the human mind.

At the average age of three years in the individual self-consciousness is born, and the infant, from the point of view of psychology, has become a human being.

For human being he is and as such is distinctly different from a mere animal. Elie Metchnikoff conveys an unwise, if not a false, impression when he declares in 'The Nature of Man' that "Man is a kind of miscarriage of the ape, endowed with profound intelligence and capable of great progress," and exception may be taken legitimately to a deduction of such sweeping force from the evidence of a certain trifling differentiation of a 'Sunset Plant,' observed by De Vries and a 'Lightning Calculator' phenomenon.

Man has no reason to be ashamed of his ancestry, and assuredly there is reason for his pride as he looks back upon the path which he has traveled and perceives the advances he has made. Emerson puts the matter strongly when he says, "Man betrays his relation to what is below him, thick-skulled, small-brained, fishy, quadrumanous quadruped, ill-disguised, hardly escaped into biped, and has paid for the new powers by the loss of some old ones. But the lightning which explodes and fashions planets and suns is in him. On the one side elemental order, sandstone and granite, rock ledges, peat bog, forest, sea and shore; on the other part thought and the spirit which composes and decomposes nature. Here they are, side by side, god and devil, mind and matter, king and conspirator, riding peacefully together in the eye and brain of every man."

The phrase now so often used, "Man's Place in Nature," has become possessed of value for the reason that it is evident his place is in Nature, not in any supernatural realm. He is part and parcel of Nature, and the biological truths which apply to the smallest and most simple organism bear a relation to him, neither can he for a fractional instant escape from the domination of the Draconic laws that govern the matter of which he is composed. There is still discussion as to whether the physical frame of man differentiated itself from the parent mammalian stock at an



a.
b.
c.
d.
 FIG. 1—HOMOLOGIES IN SKELETON ; a, ORANG-UTAN ; b, CHIMPANZEE ; c, GORILLA ; d, MAN.

early or a recent date, or to put it more bluntly, whether he is closely or distantly related to the present apes and monkeys. That he is related is beyond question, the only point needing determination is the closeness of the relationship.

"Close examination of the structure of Man has proved, in the most definite fashion," says Metchnikoff, "the exist-

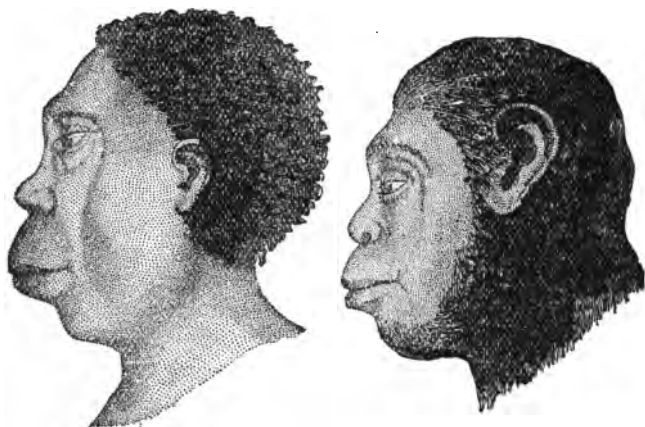


Fig. 2—FEMALE HOTTENTOT AND FEMALE GORILLA—(Winchell).

ence of a near kinship with the higher monkeys or anthropoids. Now that all the details of the human organization have been studied, and the anatomical structures of man and large monkeys without tails have been compared, bone with bone and muscle with muscle, a truly astonishing analogy between these organisms is made manifest, an analogy apparent in every detail."

Not less definite is David Starr Jordan. "We no longer think of the human race," he says, "as a completed entity in the midst of Nature, but apart from it, with a different origin, a different motive, a different destiny. Man, like the other species, is an inhabitant of the earth, a product

of the laws of life; his characters are phases in the long process of change and adaptation to which all organisms are subject. From the point of view of zoölogy, the human race is a group of closely allied species, or subspecies, undoubtedly derived from a common stock, and each species in its ramifications modified by the forces and conditions included under the several heads of variation, heredity, segregation, selection, and the impact of environment precisely as species in other groups are affected.

"It is clear that if there is an origin of species through natural causes among the lower animals and plants, there is an origin of species among men. If homology among animals and plants is the stamp of blood relationship, the same rule holds true with Man as well. Man is connected with the lower animals by the most perfect of homologies. These are traceable in every bone and muscle, in every blood-vessel and gland, in every phase of structure, even including those of the brain and nervous system. The common heredity of Man with other vertebrate animals is as well established as any fact in phylogeny can be."

These finger-posts to the past are given their due dignity by Chas. Darwin, when he says: "To my mind it accords better with what we know of the laws impressed on matter by the Creator, that the production and extinction of the past and present inhabitants of the world should have been due to secondary causes, like those determining the birth and death of an individual. When I view all beings, not as special creations, but as lineal descendants of some few beings who lived before the first bed of the Silurian was deposited, they seem to me ennobled. There is grandeur in this view of life, with its several powers having been originally breathed by the Creator into a few forms or into one, and that while this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning, endless forms most beautiful and most wonderful have been and are being evolved."

It has been the work of the biologist to trace the functions of life in its simplest form and to show the intimate relations sustained between life in the animal and vegetable world, and it has been the path of the zoölogist to depict the evolution of higher forms of animal life from the invertebrate to the vertebrate and within the latter division to the highest order the Mammals. So, to complete the picture, it becomes necessary to point out that the highest mammal treated of by Comparative Zoölogy, the Primates, contains a series, Man, which possesses as its nearest kin the ape.

The members of the Genus *Homo*, or Man, are structurally but very little removed from the anthropoid apes. The actual differences are slight and relatively unimportant when compared with the vast number of similarities that appear. Homologies of the closest sort exist, in which it is difficult to name a single point of departure. Of these the slant of the hair on the arms and body is notable. It is clear, too, that the nearest point of resemblance is to the ape, which is descended from the old-world monkey (the American or *Platyrrhine* are more divergent) and that the old-world monkey is descended more directly from the lemurs, the lowest branch of the primates. Says Jordan: "It is not supposable that any living species of Man has sprung from any extant species of anthropoid ape," a statement which will be more heartily endorsed by anthropologists than will Metchnikoff's: "Some anthropoid ape having at a certain period become varied in specific characters, produced offspring endowed with new properties."

The Simian family tie is clearly recognised by Ernst Haeckel, for he declares, "It is very difficult to show why Man should not be classed with the large apes in the same zoölogical family. We all know a man from an ape, but it is quite another thing to find differences which are absolute and not of degree only." How exceedingly true this is becomes evident when an effort is made to deter-

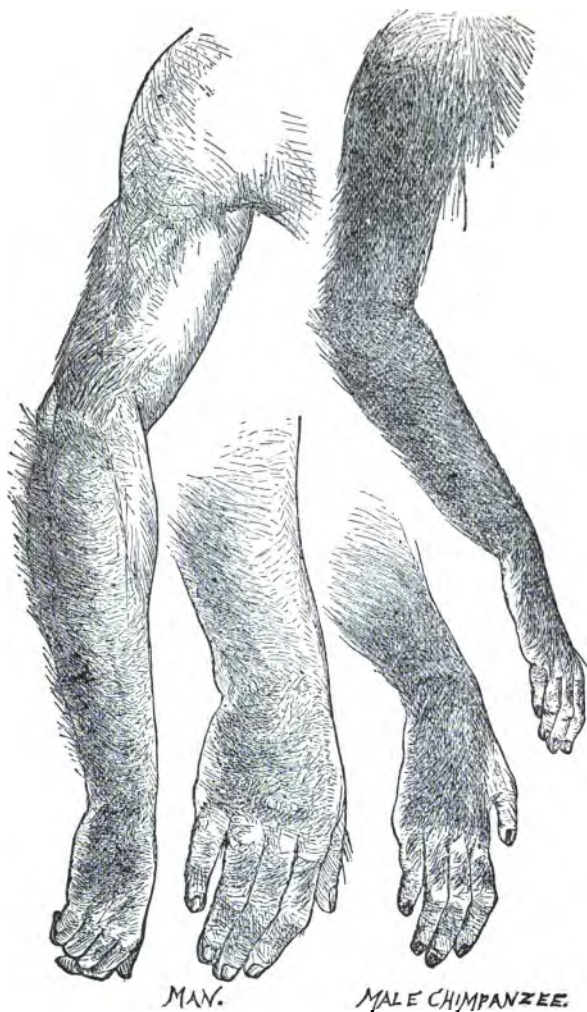


Fig. 3—HOMOLOGIES IN HAIR SLANT—(Romanes).

mine the difference between Man and Ape. These differences have been numbered as four: (1) Erect walk; (2) extremities variant, especially lower, the great toe not being opposable, the other toe little prehensile; (3) articulate speech; (4) higher reasoning power.

But the stating of these differences reveals how little variance there is. Thus several of the anthropoid apes assume the erect posture, and the much talked of "Ape-Man of Java," the 'Pithecanthropus Erectus,' was an erect ape. The difference in the toes is perhaps more clear, but the muscles and tendons which afford prehensibility in the ape are present in the Man, as the development of grasping power in the toes has been shown by men who had lost their arms in an accident, for example; while there are few who cannot pick up some such article as a handkerchief from the floor by the prehensile grip of the toes. Articulate speech, however clear a distinction, cannot be considered as a structural variance, an objection which is even more valid in higher reasoning power.

Suppose in the structural comparison the skull be taken first. In the younger apes rather than in the adults is the resemblance the most striking. Yet, unexpected as it would seem, the skull of a young orang-utan presents a better facial angle, and it might be said is a more human skull than that of the skull of an Australian Bushman. Thus, in the illustration given, it will be noticed that while the facial angle of the adult orang is distinctly more bestial than that of the adult Australian, the young ape's skull more closely approximates the young European child and is far in advance of the adult Australian.

This seems to be due to the dentition, for it is the coming of the second teeth which produces the great jaw changes, throwing forward the prognathism of the ape. Yet, even in this matter, it can be pointed out, as has been done by Metchnikoff, that the dentition of the anthropoid apes is far closer to that of man than it is to that of the other

monkeys, a point originally made with much detail by Thos. Huxley and since strengthened by a host of confirmatory evidence.

"Another character," says Metchnikoff, "which shows that anthropoids are nearer Man than other monkeys is

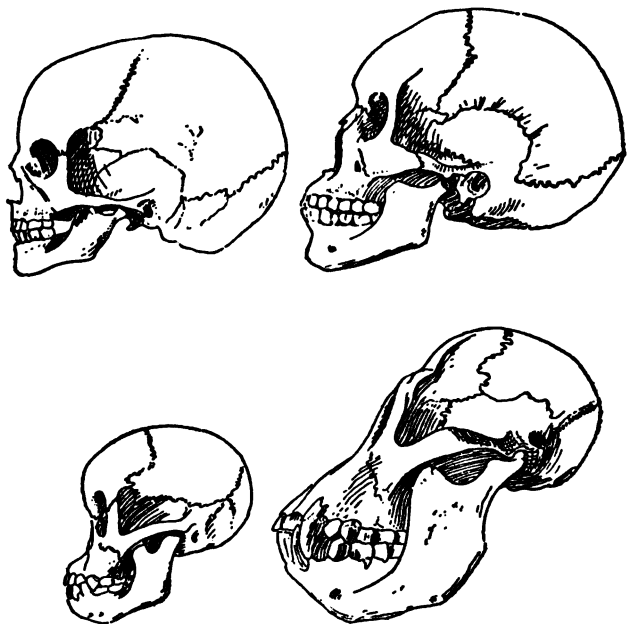


Fig. 4—SKULLS, HUMAN AND APE

Upper pair of European child and Australian adult; lower pair of young and adult orang-utan—(Wiedersheim).

furnished by the anatomy of the sacrum. In monkeys as a whole the sacrum is composed of three, or rarely four vertebrae, while in anthropoid apes it contains five; that is to say, just as many as in Man.

"The believers in the doctrine that the human species is

essentially different from all the known monkeys have laid great stress on the difference between the foot of Man and that of the anthropoid apes. This difference cannot be denied. Man assumes the erect posture habitually, while monkeys, even the highest of them, walk on two legs only occasionally. There has followed from this a greater development of the feet in monkeys. Yet this difference ought not to be exaggerated. It has been sought to prove that monkeys are 'quadrumanous' and that their hind-legs terminate in 'hind-hands.' But it is clearly shown that in all essential respects the hinder limb of the gorilla terminates in as true a foot as that of Man." Huxley is equally assured when he says: "The hind limb of a gorilla, therefore, ends in a true foot, with a very movable great toe. It is a prehensile foot, indeed, but it is in no sense a hand; it is a foot which differs from that of Man not in any fundamental character, but in mere proportions, in the degree of mobility and in the secondary arrangement of its parts."

All the arguments dealing with structural affinity are so well worn that it is useless to recapitulate them, but it is a matter of vital interest when entirely new lines of argument, unknown to Darwin, Vogt, and even Haeckel, come to light and are found to be confirmatory of the work that they had done. These two lines of comparison are found in the embryological affinity between the anthropoids and Man and the behavior of the serum of the blood of these two mammals. It is quite readily seen that embryos of the anthropoid apes are extremely difficult to obtain, and it is only very recently that M. Deniker secured a late fetus of a gorilla, the study of which has elicited many important evidences of homology.

"The placenta," comments Metchnikoff, "often gives information of great importance in the classification of mammals. It is sufficient to glance at the zonary placenta of dogs and seals to be convinced of the relationship of these two species, which at first sight seem so different.

Now the placentas of all the anthropoid apes examined up to the present (1909) are of the same discoid type as that of Man. The arrangement of the umbilical cord of Man, which was formerly considered as quite peculiar to him, is found in the anthropoid apes, as has been established by Deniker and Selenka. It is striking that the anthropoids resemble Man rather than the lower monkeys in the relation of the fetus to the fetal membranes.

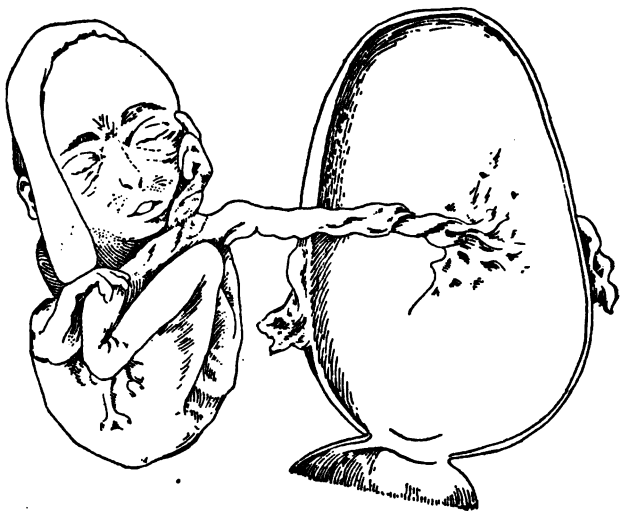


Fig. 5—FETUS OF GIBBON APE—(Selenka).

“With regard to the embryos themselves, the similarity between those of monkeys and of man is very great. Selenka insists on the fact that the youngest stages of human development that have been obtained can hardly be distinguished from those of the lower monkeys either in position or in shape. More advanced stages exhibit greater differentiation, and the later embryos of Man resemble anthropoids much more closely than those of the

lower monkeys. The fetus of the gibbon presents the most striking likeness to a corresponding human fetus."

With the line in structural development and the embryological history so clearly adduced, nothing more could be needed. Still, the differences which do exist begin early in the fetal life, showing that the branching must have been long before the development of the true ape.

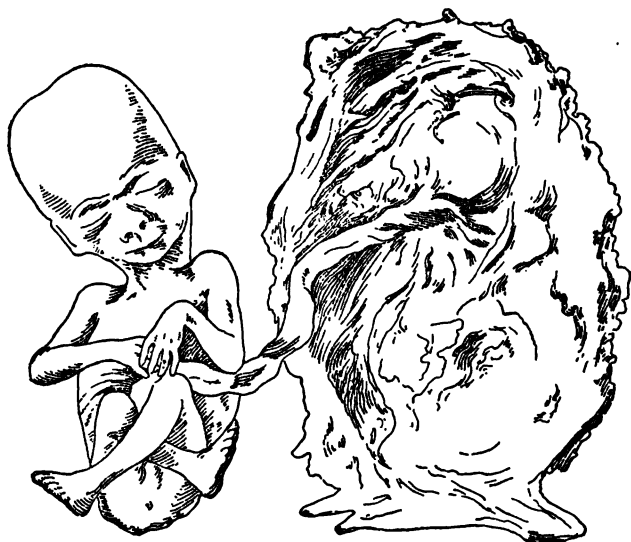


Fig. 6—HUMAN FETUS NEARLY FOUR MONTHS OLD—(Metchnikoff).

When, however, so essentially recent and conspicuously definite a discovery as that with regard to the serum is made, it may not be regarded as too repetitionary. The passages dealing with this again are taken from Metchnikoff's 'Nature of Man' for the reason of its procurability, as well as the knowledge that facts cited therein

would be authoritative, however widely the reader might dissent from the conclusions drawn from those facts.

"When the blood of one mammal is injected into the body of another, the latter shows some remarkable modifications. When there is added to a serum, prepared from the blood of a rabbit, and consisting of a colorless transparent liquid, a few drops of blood drawn from another rodent (such as a guinea-pig), nothing unusual happens. The blood of the guinea-pig preserves its normal color, and its corpuscles remain practically unaltered. If, instead of adding guinea-pig's blood to the serum of rabbit's blood, we add a serum drawn from the blood of the guinea-pig, still no special change occurs.

"If, however, a serum be prepared from the blood of a rabbit into which there had first been injected the blood of a guinea-pig, the serum shows new and striking qualities. The addition to it of some drops of guinea-pig's blood brings about, in a very short time, a changed appearance. The red liquid, at first opaque, becomes transparent. The mixture of the prepared serum of the rabbit with the blood of the guinea-pig will assume the color of claret mixed with water. The change is due to solution of the red corpuscles of the guinea-pig in the blood-serum of the rabbit.

"This serum has still another property not less worthy of attention. If there is added to it not pure blood, but only blood serum of the guinea-pig, a disturbance in the mixture occurs almost at once, and leads to the forming of a precipitate more or less abundant. The injection of the blood of the guinea-pig into a rabbit has therefore changed the serum of the latter by introducing new properties: that of dissolving the red corpuscles of the guinea-pig and of giving a precipitate with the blood serum of the same animal.

"Frequently the blood serum of animals prepared by previous injections of the blood of other species of animals is strictly specific. In such cases the serum only gives a precipitate with the serum of the species which

has furnished the blood for the injections and only dissolves the red corpuscles of this same species. But there are some instances in which a serum of a prepared animal

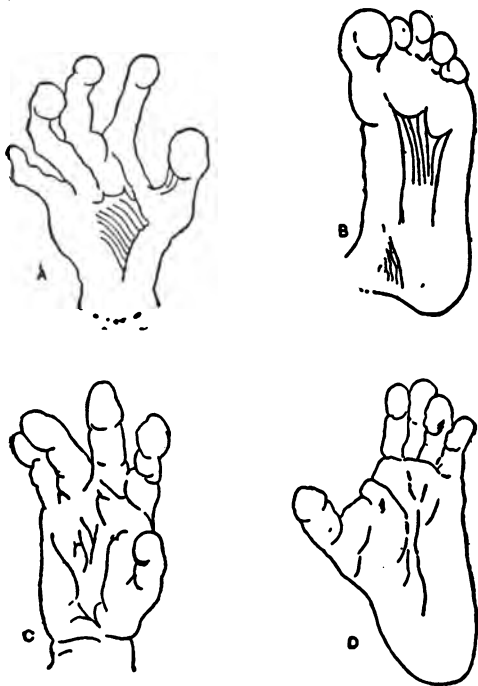


Fig. 7—EXTREMITIES OF HUMAN AND GORILLA FETUS

Showing differentiation early in the life of individual. a, Hand of human embryo; b, foot of same; c, hand of gorilla; d, foot of same—(Langley).

dissolves, not only the red corpuscles of the species which has furnished the injected blood, but those of allied species. Thus the blood serum of the rabbit, after some in-

jections of blood of the chicken, becomes capable of dissolving not only the red corpuscles of the chicken, but also those of the pigeon, tho in a less degree.

"Until quite recently it was not known how to distinguish human blood from that of other mammals. (It is a question that often arises in a court of law, particularly in criminal law). It is now found that the method of precipitates gives conclusive results. It is done in this way: Human blood is injected several times into any animal (rabbit, dog, sheep, horse). Some time afterward the animal is bled, and a clear and limpid serum, quite devoid of corpuscles, is prepared. When there is added to this serum one or several drops of human serum, it forms immediately a precipitate which falls to the bottom. In this way it is discovered whether the prepared serum is sufficiently active. It then becomes possible to recognise even dried human blood. A little of such blood is dissolved in normal salt solution and placed in a tube containing the serum of an animal prepared by means of injections of human blood. If a precipitate forms in the liquid in a short time, the fact indicates that the stain is really human blood. This method is being practiced in forensic medicine.

"How does the serum of animals which have been injected with human blood behave? The serum capable of giving a precipitate with human serum does not produce the same reaction except with the serum of some monkeys (the small Papio).

"Gruenbaum, of Liverpool, has been fortunate enough to procure a considerable quantity of the blood of three large anthropoid apes—the gorilla, chimpanzee and orangutan. He has been able to prove that the serum of animals injected with Man's blood gives a precipitate not only with this blood, but also with that of the above-mentioned apes. It was impossible for him 'to distinguish this precipitate as regards quality and quantity from that which is obtained with human blood.'

"To verify this result, Gruenbaum prepared the serum of animals injected with the blood of the gorilla, chimpanzee and orang-utan. These three kinds of serum gave precipitates with the blood of these three apes and to the same extent with the blood of Man. It is therefore evident that there exists between the human species and the anthropoid apes not only a superficial analogy of body and the principal organs, but a close blood-relationship."

To add further evidence would be gratuitous, for the human being is truly the present ultimate of evolution—so far as he can grasp it.

But Man as he is to-day will not endure. There are constant modifications proceeding in him, physical and mental, each with reflex action on the other. Nothing he knows endures; the mountain is no more nearly eternal than the castle of sand the child builds upon the beach between the low tide and the high tide marks. "I believe," said the rose to the lily in the parable, "that our gardener is immortal. I have watched him from day to day since I bloomed, and I see no change in him. The tulip who died yesterday told me the same thing."

The Science of Anthropology, then, must hark back to the earlier mammalian stock for its beginning, must consider all races of men at the present day for its momentary review, and must cast a prophetic glance forward to discern what Man shall become. Its economic value lies in determining what are the lines of direction progress is taking and in pointing out the manner to follow those lines, to the end that Nature may be rightly helped, not hindered. Not that Nature needs help, but that Man, if he ignorantly endeavors to pursue a path not intended for his feet, first will suffer cruelly and at the last be cast aside.

CHAPTER II

ANTHROPOMETRY

It is an idiom of general use to declare that a particular person 'has the ear-marks' of a certain definite type, and while this phrase probably has evolved in America from the ear-marking of cattle in the West, yet it is not the less true in a nearer instance that might be given. For ear-marks are indeed one of the many definite measurements which are not only peculiar to Man as a whole but to the individual man.

It may, perhaps, be going too far to say that the study of Anthropometry is one wherein every person is a scholar, but none the less it is most amazingly true that the actions of men's lives are modified by their intuitive or experience-taught understanding of the measurements of their fellow-beings. It has been wisely said that "had Cleopatra's nose been a little shorter it would have changed the map of Europe," and it seems not less likely to be true that had it been a trifle longer the same effect would have been apparent. Had Helen of Troy possessed a cast in the eye, where would have been the Iliad and the Odyssey, and would there have been the chivalrous loyalty in the court of Elizabeth if the Virgin Queen had been a sour-visaged shrew? Yet it must be admitted that between supernal beauty and eldritch ugliness is but the fraction of an inch here or there.

Before going into the more scientific measurements and their implications, it may be well to show that there are

certain of these which are indubitably familiar to every observer. Thus a man who cannot look you squarely 'between the eyes'—that is, whose eye muscles are not sufficiently under control to meet your gaze—will rarely be trusted. He is thought (and often rightly) evasive, underhand and untrustworthy. Where the eyes are large and lustrous an affectionate disposition is expected, when they are steely blue and extremely rapid in their glances from object to object, quickness of wit and instancy of decision are encountered.

How generally are the measurements of the lips taken in such hasty decisions. Ripe, red lips, moist and partly open, seem to convey an invitation to dalliance which is certainly absent in the thin, hard, dry line of the angular and embittered spinster. Likewise a mouth kept partly open most of the while is often a sign of vacuity of mind and uncomprehending surprise, while a firm, determined set of the lips and of the chin reveals a character thoroly comprehending the goal sought and insistent on securing the point of attainment sought. In contrast to this, again, the receding chin is taken to imply mental weakness and lack of purpose.

So a low, receding forehead and a development of the back of the head is so well known that in common speech it is called a 'criminal head,' while if it be coupled to a mowing of the jaw and a certain glassy stare in the eyes it is interpretative of some forms of idiocy. Even the eyebrows play their part, and it is familiar to hear of frowning eyebrows implying fierceness of temper, of supercilious eyebrows implying a character prone to the use of the critical faculty, and tilted eyebrows are often esteemed the sign of an unready nature. The list could be multiplied to great length, and these merely have been mentioned, not in the sense that scientifically speaking they do really portray the characters to which they have been assigned, but to show that a relation of character to physical measurement is popularly assigned.

A still more striking evidence of this is seen in the matter of resemblances. The actual variances of measurement between two brothers or two sisters often are very slight—so far as the face goes, they require the most exact instruments to record them; yet the eye at the same time perceives a similarity and a difference. But for this ability of the eye to grasp readily the infinitesimal differences in features, all family life would come to a standstill; the husband would not know the wife nor the wife the husband, and neither children nor parents could be sure of their relationship.

Commerce and trade would come largely to a standstill, for there could be no system of credit if the buyer and the seller were unable to recognise each other. It forms an interesting speculation, indeed, to try and devise a world which should be in all respects as this, yet lacking the anthropometrical sense. It is certain that it would modify profoundly the civilization of to-day.

The race question would take on a new aspect, for gradations of color really belong to anthropometry and certainly physiognomic comparison also. The Chinaman and the Negro and the Caucasian are easily told apart, but only because of color and of measurement. Nay, even the difference between a man and an ape, between an ape and a dog and so forth are again merely matters of measurement.

In Ethnology, generally, no little use will be made of anthropometrical measurements, for the reason that they afford a true basis for divisions of races. Thus the oblique slant of the eyes is a Mongolian sign, the prognathous jaws and intumescent lips reveal the Negro, and the high facial angle indicates the Caucasian. To touch on other structural differences, may be mentioned the well-known facts of the greater length of arms among the negroes and the hindward projection of the heel in a manner similar to that of the anthropoid apes.

Of recent years, however, a new value has been given

to anthropometry by its use in criminology, or the dealing with the various types of criminals that infest society. This, because it has been carried to its highest degree of efficiency, as well as because most of the origination and development of the plan was done by Alphonse Bertillon, is known as the Bertillon system.

An admirer of Bertillon, Prof. Persifor Frazer, in a recent article (1909) in the *Journal of the Franklin Institute*, has gone so far as to declare that the system is the answer to the question, "Of what use is Anthropology?" This is an extreme viewpoint, for Anthropology has a score of other avenues of economic value, but it contains enough truth to point out the exceeding value of such measurements in Criminology. Indeed, it lies entirely within the purview of this subject to give a brief sketch of the Bertillon system, its nature and its mode of operation.

If the aphorism be true that 'genius is the capacity to take infinite pains,' Bertillonage is an example of the highest genius, for its successful application depends upon a delicate unperturbed appreciation of physical sensations on the part of the observer, a scrupulous accuracy in recording observable data, and the use of all the precautions known to original investigation by repetition of measurements and readings to avoid possible error.

Broca, a member of the first *Société d'Anthropologie*, of Paris, proposed a color scale for describing the eyes and skin of different races of men. The characteristics which he regarded as most valuable in distinguishing races were, first, the color of the skin, and, second, the structure of the skull, and their importance in the order given.

According to Retzius' method, very generally adopted by anthropologists, the longer diameter of the skull from front to back is assumed as 100. If the shorter diameter measured above the ears is less than 80 on this scale, the skull is called dolichocephalic (long-narrow headed); if more than 80, brachycephalic (short or round headed).

From 75 to 80 in the transverse diameter he called mesocephalic. Negroes have 72, Europeans 78, and Tartars 88, in this measure. The application by M. Bertillon of these methods was for the identification, not of great groups of the human family—races—from each other, but of an individual from every other individual, and arose from the urgent need of the law courts to know whether they were dealing with old offenders (*recedevistes*), or whether an arrested man actually had not been previously before them.

M. Bertillon's system is divided into, first, a means of identifying an individual with absolute certainty, from careful measurements taken by skilled agents, and, second, a ready means of recognising an individual in a crowd from a description or from observations previously taken. One supplements the other, while each is useful independently of the other.

The principle upon which the measurements are based is that no things are absolutely identical, however similar they may seem. This is especially true of organic objects which grow, because it is unthinkable that two different and separate beings could be, during a number of years, subjected to exactly the same forces, and should present to these forces exactly the same resistances. Whatever it be, whether two coins struck from the same die, twins who have been fed and nurtured similarly, even two drops of water taken from the same source, a sufficiently minute examination will inevitably disclose differences which will be greater and more numerous the more searching and careful is the investigation. It is only necessary then to obtain a sufficient number of data from each individual to place upon record a description which will differ from that of any other individual analogously made.

This identification is confined to the two measurements of the head with callipers fixed successively to the figures given in the description already on file. These two data taken and corroborated to a millimeter ($\frac{1}{8}$ inch) are

amply sufficient to determine whether or not the prisoner has told the truth. It is thus at once seen whether the same individual is present, and if so no further measurement is made. When the same offender has been identified five times he is banished.

As rapidly as possible those who are subjected to a further examination are called into the large adjoining room where three separate sets of measurements can be undertaken at the same time. In each case the same agent obtains the following anthropometric measurements, the portrait parlé description, and the peculiarly characteristic marks, which are recorded by a clerk occupying an elevated desk very much as the measurements are taken in the better class of tailor shops.

The Long Diameter of the Skull.—This is obtained by means of adjustable callipers with a binding screw to fix the arms at any position. The measure is made from the cavity at the root of the nose to the point of greatest protuberance of the occiput. Two measures are made to control each other.

Transverse Diameter of the Skull.—This is taken by means of the same callipers and is the maximum distance apart of the parietal bones which are situated above the superior border of each ear.

The length of the middle finger, the span with both arms outstretched, the length of the left forearm, the height, the height of the trunk and the length of the ear are all determined. The Bi-zygomatic Diameter has in part replaced that of the right ear. It is taken by means of the same callipers, between the osseous bands which terminate above the auditory canal and behind the cheek bones. In French adults it varies between 137 mm. and 138 mm. (about 5.39 inches).

“It is evident at the first thought,” says Prof. Frazer, “that the most permanent data will be found in those parts of the body which undergo the least change; in other words, the bony structure; and of all these the skull, which

from an early age, in spite of its twenty-two component bone-plates, is virtually a single large bone, proves the most available for identification because important artificial alteration of its dimensions is almost or quite impossible." (The skull of the adult of course is referred to here, as the savage deformations of the skull are done in childhood.) The pivotal point of the Bertillon measurements is therefore the skull and the relation to each other of its anteroposterior and transverse diameters.

Two other means of identification of the highest importance have been added to the anthropometric measurements of M. Bertillon, the finger-prints and the shades of color in the eye.

The study of the finger-prints is perhaps the most picturesque of all the Bertillon points. It is an addition to the system and is so recognised, and the credit seems to be assigned to Sir William Herschel when he was Collector of a district in Bengal. Altho it was handled there in modern methods, the true importance of it did not appear until 1888 when Francis Galton, having given it extensive study, announced to the scientific world the conspicuous value of the system and illustrated his arguments with examples that allowed of no further question. The setting forth was exhaustive and conclusive.

Altho Galton is on record as having said that his attention was drawn to the matter by a personal investigation of the Bertillon system, the French bureau for some years paid no attention to it until M. Bertillon saw that it would afford an absolutely final support in the verification of criminals. Galton's system was slightly modified, and a nomenclature and method arranged which is now complete in every detail. To this end the four vowels "e," "i," "o," and "u" are used to indicate the four types into which the patterns of the finger prints are divided. Loops resting on the usual triangle of intersection near the middle of the impression extend from left to right downward; their closed ends being above and to the left, and the free ends

descending to the right. To justify the designation there must be at least two such loops.

The type "i" is that pattern where at least two ridges indicated by black lines in the impression have their closed

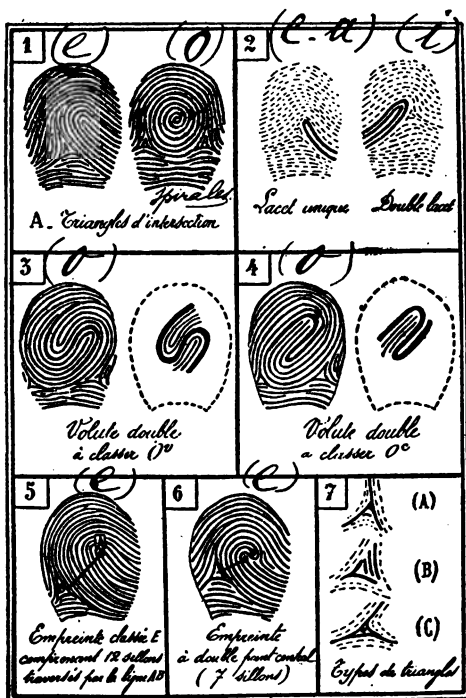


Fig. 8—TYPES OF FINGER PRINT PATTERNS

ends to the right, above the triangular places of intersection, forming an oval, or spiral, the latter either concentric or as volute.

The type "o" is that where the digital lines appear to the number of at least 4 between the little triangular pat-

terns marking the central point of each finger tip; and their form is oval, spiral, or volute.

The type "u" is that pattern in which the lines are superposed in the form of an arch, flat near the bottom and higher on top.

An interesting practical application of this method appeared in the mysterious Steinheil-Japy murder case which had been agitating Paris in the winter of 1908. In this instance the invisible network of greasy exudation from the papillary ridges of various hands which grasped a bottle of cognac had been traced to the possessors of these hands, the prints being dusted with finely powdered white lead.

Another case, taken at random among thousands, was as follows: On April 30, 1906, a man was arrested and measured under the name of Giard. On September 4, 1908, a prisoner was measured, giving his name as Giraut. Tho 27,739 persons had been measured in the interval he was identified by the finger-prints in less than five minutes.

The Examination of the Left Eye.—The eye is a means of identification as important, in M. Bertillon's estimation, as the marks of the finger prints. The color does not change with age. So far as its color is concerned, M. Bertillon asserts, the eye is unchangeable from birth to death. M. Bertillon has made a table of seven categories of color. The categories are based on the increasing intensity of the yellow-orange pigment. The pigment is a reddish or brownish yellow animal matter which gives to the eye diverse tints. When the pigment increases in quantity in an iris, the eye from the point of view of its color, and of the number in its class, increases also.

In other words, the more pigment an eye contains the more it appears dark, and close to the extreme type of pure horse-chestnut color. Eyes called unpigmented are not deprived of all color, but are uniformly blue, and the opposites of the pure horse-chestnut brown color. This type of eye is found among the Slavs and the people of the

North, the other type among the negroes, the Arabs, and more generally the dwellers in the South.

The function of the anthropometric service is to obtain from the prisoners brought to it a certain number of osseous measurements, using the figures thus obtained as a basis to classify the photographs of individuals, after the manner of a classification of flora, etc., to enable one ulti-

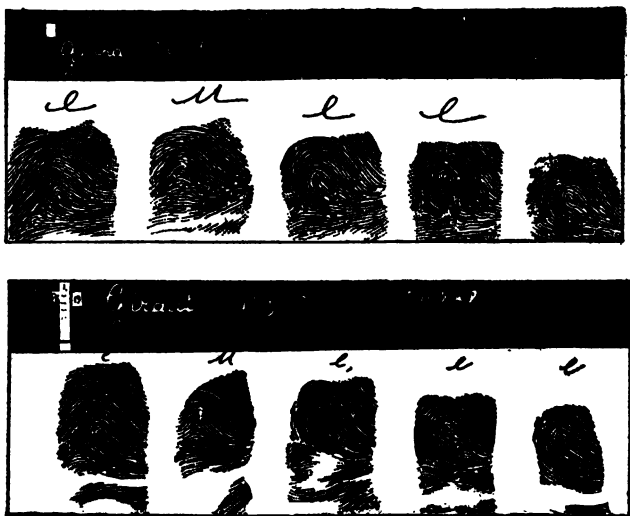


Fig. 9—RECORD OF CRIMINAL'S IDENTIFICATION—(Fraser).

mately to find, in a collection destined to contain several hundred thousand specimens, the portrait of an old offender who has concealed his identity under a false name and a disguise.

Suppose the collection to contain sixty thousand records. The first division is based on the longer diameter of the skull. In all cases the order is from small to great. Then

the division containing records of these would be: short heads, 20,000; medium heads, 20,000; long heads, 20,000.

Each of these three divisions of 20,000 is further divided into: narrow heads, 6,000; medium heads, 6,000; broad heads, 6,000.

Each of these three divisions of 6,000 is further subdivided into: long middle fingers, 2,000; medium middle fingers, 2,000; short middle fingers, 2,000.

Each of these last divisions of 2,000 is further subdivided into: short left foot, 600; medium left foot, 600; long left foot, 600.

These again into: long left forearm, 200; medium left forearm, 200; short left forearm, 200.

These further into: small little finger, 60; medium little finger, 60; long little finger, 60.

These into: long right ear, 20; medium right ear, 20; short right ear, 20.

These into heights: short, 6; medium, 6; tall, 6, and these six remaining from the 60,000 original cases are further differentiated by the color of the eyes. So that but a few minutes would elapse from the first glance into the head-length box till the agent had traced the individual whose record-slip was given to him down to the ear-division, and selected by the eye-color determination which of the six slips if any correspond to that in his hand.

When in addition the finger prints are available, it is clear that possibility of mistake is eliminated. In more than 2,300 recognitions thus transmitted to the trial magistrates not a single one has caused the confusion or embarrassment which a mistake would have been sure to occasion.

M. Bertillon has strictly forbidden his employees to inform the interested individual when he has been identified. A few notes are taken and he is dismissed to the depot, but the facts are put into the possession of the magistrate who is to try him, and this will explain the frequent dramatic sensations produced. The prisoner is arraigned before the

magistrate. He has answered that his name is Jean Bourdet, a carpenter, living in the Rue Mesnil, that he is unmarried, and twenty-four years old. Whereupon the genial justice replies: "Your name is Eugene Tridot; you were arrested for highway robbery and attempted assassination on June 17, 1902; you were also imprisoned for beating your wife almost to death; you were born in Lyons, are thirty-seven years old and have served three terms of imprisonment; this is your fourth appearance and last chance; your present punishment must bear relation to your former crimes, and if you are ever again in the hands of justice, banishment inevitably will follow."

Professor Frazer touches a point of vast importance when he reveals the potency of the Bertillon system not only in identifying criminals, but in convincing offenders against society that recognition is inevitable and penalty swift and sure; while, even more than this, it becomes a most efficacious prevention of crime. When it is no longer possible to dodge the law, illegality diminishes. Again, the same writer points out: "If the identification be so perfected, and so universally adopted, that recognition of a person who has been Bertillonized is positively certain, will it not be possible so to modify the penal legislation that the trials and condemnations of criminals shall proceed to their ultimate punishment of the guilty without the use of names at all? In this way the innocent parents, brothers and sisters of a degenerate may be spared the added humiliation and suffering of seeing the name they bear and have tried to make honorable associated with some revolting or contemptible crime."

This is but one of the avenues of advancement which the study of Anthropometry affords. It possesses especial force because of its practical nature and the intense amount of energy inherent to it in the suppression of crime, in the advancement of civilization and in the general welfare of mankind.

CHAPTER III

THE UNITY AND THE VARIETY OF MAN

RACE hatreds evoke many curious problems. There are people to whom it is less disturbing to think that in the remote past their ancestors might have appeared more simian than it is to think that under present conditions they are members of the same species as the Negro, the Chinaman, the Digger Indian, or the cannibal of the south seas. Yet this is a point which admits not of dispute, for by the law of Fertility, which physiologists now agree in accepting as a leading test of varietal and specific difference, all races of Man are, and have been for ages, permanently fertile, while such a condition does not exist, and, indeed, cannot be forced to exist, between Man and any other species.

This possibility of miscegenation is extremely obvious in North America, so much so that it would scarcely need to be pointed out save to show that if it were not so Ethnology would have no problems to consider at all; for on the one hand and on the other would be races complete, their respective characteristics continuing without any direct change—and there would be an end of it. But Ethnology faces one of the most complex of all problems, for the reason that the entire readiness of one race to absorb and of another to be absorbed, coupled with the unwavering persistence of certain peculiarities (not always the most obvious), obliterates all hard and fast lines of division and reveals the imperceptible gradations by which one race shades into another.

If it were feasible to produce a map of the populated world wherein the particular color scale of each district could be painted in, all following a definite average, the colors ranging from the flesh color of a northern Scandinavian to the almost jet black of certain Negro tribes, such a map would appear greatly mottled owing to the manner in which certain settlements of variant races have strayed in. Viewed from a fair perspective, the shading from fair to dark would reveal blending everywhere and harsh lines of division nowhere.

This same difficulty becomes apparent also in the remains of Prehistoric Man, altho this point is often curiously ignored. Thus, it does by no means follow that the discovery of a certain paleolithic skull in a certain locality presupposes the existence of a race of men markedly similar. This objection ceases in the later neolithic times, when an abundance of remains yields definite averages. Certain discoveries, however, point to an earlier physical form of Man than any which are now known, and these have formed the basis for much anthropological argument. The men of Neanderthal, of Spy, of Laugerie-Basse, and the latest of all—the *Pithecanthropus Erectus*, or “the fossil ape-man of Java”—have formed the basis, respectively, for an immense amount of description, of comparison, and of surmise.

The discoveries of the actual osseous remains of primitive man are of vast importance, but they are very few. Thus, for example, the *Pithecanthropus Erectus*, around which so much comment and criticism has gathered, is deduced merely from the roof of the skull, and one tooth and one thigh bone which may or may not have been part of the same creature. A. H. Keane, in his ‘Ethnology,’ has classified the remains worthy of credence as follows:

“Trinil (*Pithecanthropus Erectus*), found on the left bank of the river Bengawan, Java. Roof of skull, an upper molar and a femur, found (1894) by Dr. Eugene

Dubois in pleistocene (?) bed 12 to 15 meters below the surface. Showing characters intermediate between gorilla and Neanderthal, but distinctly human, low depressed cranial arch; 'the lowest human cranium yet described, very nearly as much below the Neanderthal as this is below the normal European'; femur quite human; tooth very large but more human than simian.



Fig. 10—REMAINS OF NEANDERTHAL MAN

"Neanderthal, a brain-cap, two femora, two humeri, and some other fragments; remarkable for its flat, retreating curve; the most apelike skull, next to the *Pithecanthropus Erectus*.

"La Naulette, Belgium, an imperfect lower jaw; simian

characters very pronounced in the extreme prognathism and alveolar process.

"La Denise, France, two depressed and retreating frontal bones, glabella of one very prominent, recalling the Neanderthal; that of the other also prominent, and separated from the retreating frontal bone by a deep depression.

"Brux, Bohemia, a brain-cap and other bones; frontal region and flat, elongated parietals like those of Neanderthal and Eguisheim, but superciliary bosses larger than the latter.

"Spy, Belgium, two nearly perfect skeletons (man and woman); enormous superciliary ridges and glabella, re-

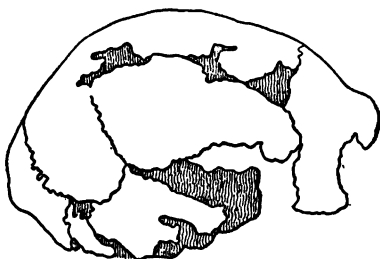


Fig. 11—SKULL OF THE MAN OF SPY

treating frontal region; extremely thick cranial wall, massive mandibular ramus with rudimentary chin. Large posterior molars; divergent curvature of bones of forearm; tibia shorter than in any known race, and stouter than in most; tibia and femur so articulated that to maintain equilibrium head and body must have been thrown forward as in the largest apes.

"Galley Hill, England, nearly perfect skeleton, skull extremely long, narrow, and much depressed; glabella and brow ridged, prominent; forehead somewhat receding; height about 5 ft. 1 in.; altogether, most nearly related to the Neanderthal, Spy, and Naulette types.

"Podbaba, Poland, fragment of skull; approaches the Neanderthal type.

"Predmost, Bohemia, fragments of skeletons of six persons, similar to Neanderthal type; that of man wonderfully complete, and of gigantic proportions.

"Marcilly sur Eure, Belgium (?), part of skull, also of Neanderthal type.

"Arcy-sur-Eure, Belgium (?), lower jaw, somewhat modified Naulette type.

"Olmo, Italy, skull; above that of Neanderthal. A doubtful find.

"Eguisheim, Germany, part of skull, prominent super-

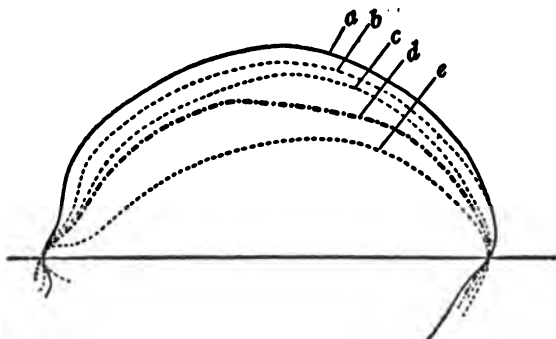


Fig. 12—COMPARISON OF CRANIA

a. Average European skull; b, Spy; c, Neanderthal; d, pithecanthropus; e, gorilla.

ciliary ridges, frontal region broad but retreating, sutures simple and nearly effaced.

"Laugerie-Basse, France, one skeleton (male), two skulls (female); thick parietals; cranial capacity above the modern average in the male and in one female skull, but in the other female very low.

"The foregoing," says Keane (writing before the recent discovery of Chapelle-aux-Saints), "belong to various paleolithic epochs, and while all, without exception, are

dolichocephalic (index ranging from about 70 to 75), the distinctly low characters show progressive modifications in the direction of the higher neolithic and modern types." Keane goes on to point out that both in France and England, following a large number of finds, the earliest men "appear to have been first of long, then of medium, and lastly, in some places, of exclusively round-headed type (of skull)."

If, then, the early times reveal the possibilities of indefinite crossings and intermarrying among variant races, it is next in order to point out that such intermarrying is permanent, and that, far from producing a weak breed, it possesses a definite strength of its own. The statement made by Dr. Robert Dunn, in his 'Unity of the Human Species,' that "half-castes very generally combine the best attributes of the two races from whence they originate," might be somewhat qualified.

In the far north the Dano-Eskimo half-breeds of Greenland are becoming the dominant race; in Canada the famous French Canadian-Algonkian voyageurs were among the hardiest races ever seen; in the United States the high birth-rate of mixed negro and white blood is well known; and in Brazil the cross between the first Portuguese immigrant and the aborigines, the so-called "Paulista" half-breeds, are "the most vigorous and enterprising section of the community."

In Africa, the 'bastards,' or Hottentot-Dutch cross—could more dissimilar races be selected!—form flourishing communities in Griqualand, and are known as Griquas; the Negro-Hottentots have crossed to form the Gonaquas; the Gallas are Negro and Hamite; the Abyssinians are Negro, Hamite and Semite.

In Asia, the Baltis are part Mongol and part Aryan, the Dravidian aborigines mix with the Aryans to their profit, and the Franco-Annamese in Cochin China, known as the Minh-huongs, are said by M. Morice to be increasing in number, to be well adapted to climate, and to pos-

sess powers finer than their former savage race. Certain of the Oceanic Islands, such as the Philippines, have all the four varieties of the human species intermingled.

The famous Pitcairn Island mutineers are a historic case. In 1789 the mutineers from an English ship, the 'Bounty,' nine in number, all English, were marooned on Pitcairn Island, with six male and fifteen female Tahitians. Strife was constant over the possession of the women, and when the island was next visited, four years later, five of the English sailors, all the Tahitian men, and five of the Tahitian women had been killed. The four remaining Englishmen had made a partition among themselves of the ten Tahitian women, realizing that life would be impossible if every man's hand was against his neighbor. In 1825 the colony had increased to 66 persons, and in 1891 to 120. The islanders are very dark in complexion, but possess Caucasian features; their intelligence is of a fine order, and their physical resistance is high.

"It may be concluded on inductive evidence," comments Keane, "that all the Hominidae (Man) are, and always have been, permanently fertile with each other. Eugenesis (indefinitely fertile miscegenation) is the norm, and to it must, in fact, be attributed the endless varieties of mankind, which may be said to have almost everywhere supplanted the few original fundamental stocks."

The first serious attempt at a systematic grouping of the races of Man was made by F. Bernier (1625-1688), who distinguished four types: the European white, the African black, the Asiatic yellow, and the northern Lapp! Linnaeus (1738-1783) followed with his 'Homo monstruosus,' 'Homo ferus,' and 'Homo sapiens.' The 'Homo ferus,' being dumb, and covered with hair, answers somewhat to Haeckel's 'Homo alalus,' while the group 'Homo sapiens' comprises four varieties: the fair-haired, blue-eyed and light-skinned European; the yellowish, brown-eyed, black-haired Asiatic; the black-haired, beardless, tawny

American; the black, woolly-haired, flat-nosed African. Blumenbach (1752-1840) followed with his five varieties bearing a nomenclature that still largely persists: 'Caucasic,' 'Mongolic,' 'Ethiopic,' 'American' and 'Malay.' But Blumenbach later (1795) fell back on Linné's four varieties, which, however, he distributed somewhat differently, assigning to the Caucasic most of Europe, Cis-gangetic Asia and the region stretching northward from the Amur basin; to the Mongolic Trans-gangetic Asia north to the Amur "with the islanders and great part of the Austral lands"; to the Ethiopic, Africa; and to the American, all the New World, except the northern coastlands—that is, the Eskimo domain—which he includes in the Mongolic division."

Then ensued a period of orthodox reaction against the Lamarckian ideas headed by Cuvier (1773-1838), who held by fixity of species, but inconsistently admitted three races, the Caucasic, Mongolic and African, supposed to answer to the biblical Japhetic, Semitic and Hamitic families. In 1801, Virey (1775-1840) reduced Cuvier's three divisions to two distinct 'species,' white and black, each with three main 'races' or subspecies, which again comprised a number of secondary groups. But this could not satisfy thoro-going polygenists,*such as Desmoulins, who started eleven human species in 1825, and the next year raised them to sixteen; Bory de Saint-Vincent, who in 1827 discovered fifteen species, including such nebulous groups as "Scythians," "Neptunians," "Columbians"; lastly, the American school, which, in the hands of Morton, Gliddon, Knox, Agassiz, and others, brought about an inevitable reaction by threatening to increase the number of species indefinitely. Other groupings, which were marked by greater sobriety, and which still possess some historic interest, were those of Hamilton Smith (Caucasic, Mongolic, Tropical); Latham (Japhetic, Mongoloid, Atlantides); Karl G. Carus (four divisions somewhat fantastically named 'Nachtmenschen,' "Night-men," the Ne-

gro; 'Tagmenschen,' "Day-men," the Caucasian; 'östliche Dämmerungsmenschen,' "Men of the eastern twilight," Mongolo-Malayo-Hindu peoples; and 'westliche Dämmerungsmenschen,' "Men of the western twilight," the American aborigines); and Peschel (Australian with Tasmanian, Papuan, Mongoloid with Malayo-Polynesian and American, Dravidian, Hottentot with Bushman, Negro, Mediterranean—i.e., Blumenbach's Caucasian).

A fresh element of confusion, which still clings to ethnological studies, arose out of Frederick Schlegel's little treatise on the "Language and Wisdom of the Hindus" (1808), which was later declared by Max Müller to have revealed a new world, and to have shown what unexpected services Anthropology might derive from the science of language. The extreme views of the ensuing philologists were countered by Nott, Gliddon and Knox, who suggested an unlimited number of human species and varieties.

Meanwhile, the way had been prepared for a more rational treatment of racial diversity by Dr. James Cowles Prichard, who, not without reason, is by many regarded as the true founder of ethnology as a distinct branch of general anthropology. At least, suggests Keane, he may share this honor with Buffon, who, so early as 1749, had undertaken 'l'Histoire Complète de l'Homme,' as a part of his great work on the Animal Kingdom (1749-1788).

His 'Crania of the Laplanders and Finlanders,' continued by the more solid work of the elder Retzius in the same field, gave a fresh impulse to craniological studies which had already been cultivated by Morton, and on which Geoffroy Saint-Hilaire based his four fundamental types: orthognathous, eurygnathous, prognathous and euryprognathous (1858). Thus were laid the foundations of the comparative study of the Hominidae based on their physical characters, a line of inquiry which, in the hands of Broca, de Quatrefages and Hamy ('Crania Ethnica'), Topinard, Virchow, Kollmann, Mantegazza,

Pruner Bey, Barnard Davis, Beddoe, Huxley, Thurnam, Turner, Rolleston, Flower, Macalister, Garson, Cope, and others, has led to fruitful results.

Among these latter it is notable that a great emphasis is laid upon the hair. Thus Ernst Haeckel made a division into two, the Ulotriches, or Woolly-Haired, and the Lissotriches, or Lank-Haired, the former of which he divided into Tufted and Fleecy and the second into Straight and Curly. De Quatrefages remained faithful to color, and divided the Human race into White, or Caucasian; Yellow, or Mongolic; Negro, or Ethiopic. Huxley followed the division of Bory St. Vincent, of Ulotrichi, Woolly-haired, and Leotrichi, Smooth-haired, and divided the latter into four divisions on the ground of color. Broca made a tripartite division on the basis of hair, Straight-haired, Curly-haired and Woolly-haired, divided that again by the shape of the skull, and then subdivided on the basis of color. Müller followed the line of Huxley. J. Deniker devised a complex scheme on the basis that every ethnical group results from a fusion of races, and therefore all such groups must possess types, which cross and commingle in a bewildering fashion. It also is notable in the hair relations between man and ape as shown in Fig. 3 and Fig. 13. In the latter the embryo and the 'dog man' are both more hirsute than the gorilla.

From a general survey of the various schemes it appears that special, if not paramount, importance is given by these systematists to the three elements of complexion, character of the hair, and shape of the skull. Precedence may be claimed for color, at least as the element which occurs first to the observer, and on which, probably for that reason, the first groupings were determined. It appears that the pigment, or coloring matter, situated chiefly in the 'rete mucosum,' or lower layer of the cuticle, which was formerly supposed to be peculiar to the Negro, is really common to all races, only more abundant, and of darker hue, in the Negro, the Papuan, Australian and Oceanic

Negrito. Nor is there any necessary correlation between this darker hue and other Negro characters, as appears from its presence in many Somal, Galla and other Hamitic and even Semitic groups of quite regular features.



Fig. 13—FACIAL HAIR OF MAN AND APE

Upper pair, front and side views of gorilla—(Brehm).

Lower pair, human embryo five months old (Ecker) ; and Andrian Jeftichjeis, "the Russian dog man."

It is important to note that the palms and soles of the Negro are never black, but always yellowish, that the dark pigment is wanting in the Negro fetus, and that Negro children are born, according to Waitz, "of a light

gray color." Hence it might be inferred that the dark color, with which a thicker skin is correlated, is a later development, an adaptation of the organism to a hot, moist malarious climate, in which the Negro thrives and the white man perishes.

"Thus color, taken alone," says A. H. Keane in his 'Ethnology,' "cannot be regarded as an entirely trustworthy test of race, the less so that even blackness is not an exclusively Negro character, but common also to many eastern Hamites (Agaos, Bejas, Somals, Gallas), and to numerous aborigines of India. Nevertheless, it is far too important a factor to be overlooked, and taken in combination with other characters will lead to satisfactory results. Although the transitions, as in other physical traits, are complete, there appear to be about six primary colors to which all the human groups may be referred, as under:

"Black.—African and Oceanic Negroes; Australians; Tasmanians; some aborigines of India and America; Eastern Hamites.

"Yellow.—Mongols; Indo-Chinese; Japanese; Tibetans; some South Americans; Bushmen; Hottentots.

"Brown.—Polynesians; Hindus; Plateau Indians of America; many Negritoes; Fulahs.

"Coppery red.—Prairie Indians ("Redskins").

"Florid white.—Northern Europeans; Lapps; Finns; Xanthochroid Caucasians generally.

"Pale white.—Southern Europeans; Iranians; many Semites and Western Hamites; Melanochroid Caucasians generally."

The hair, if not regarded as of more importance than the complexion, has steadily risen in favor with systematists, especially since a paper by Pruner Bey "On the human hair as a race character, examined by the aid of the microscope," before the Paris Anthropological Society, 1863. Since then this element, previously little attended to, has been made the base, or leading character,

in the groupings of some of the most eminent recent ethnologists. The reason is that both color and texture of the hair are found to be extremely constant characters, resisting time and climate with wonderful tenacity, and presenting remarkable uniformity throughout large sections of the human family. Thus all the American aborigines, from Fuegia to Alaska, as well as most of the Mongoloid, Malay, and Eastern Polynesian peoples, are invariably distinguished by the same black, lank, somewhat coarse and lusterless hair, round, or nearly round, in transverse section. No other single physical trait can be mentioned which is to the same extent characteristic of several hundred millions of human beings distributed over every climatic zone from the Arctic to the Antarctic waters, and ranging from sea-level (Fuegia, Mackenzie estuary) to altitudes of 12,000 and even 16,000 feet (Bolivian and Tibetan plateaux). So, also, short, black, woolly, or at least crisp, or frizzly hair, elliptical and even somewhat flat in transverse section, is a constant feature of the Negroes, Hottentots, Bushmen, Negritoes, Papuans, Melanesians, Tasmanians, in fact of all the distinctly dark Negroid populations, say, of 150 million members of the human family. Lastly, hair of intermediate types, black, brown, flaxen, red, smooth, wavy or curly, and generally oval in transverse section, prevails among both sections of the Caucasian division, which may now be estimated at 700 or 800 millions.

From Pruner's microscopic studies it appears that, apart from its color, the structure of the hair is threefold:

1. Short, crisp or fleecy, usually called "woolly," elliptical or kidney-shaped in section, with mean diameters 20:12 in hundreds of millimeters; no perceptible medullary tube, and often relatively flat, especially in Papuans; color almost invariably jet black; characteristic of all black races except the Australians, and aborigines of India.
2. Long, lank, of the horse-mane type, cylindrical, hence round, or nearly so, in section, with diameters either about 24, or,

if elongated, 27:23; distinct tube, filled with medullary substance; color mainly black or blue-black; characteristic of all American and Mongoloid peoples. 3. Intermediate, wavy, curly or smooth; oval in section, with long and short diameters 23:17 or 20:15; distinct tube, but empty or diaphanous; all colors from black through every shade of brown to flaxen, red and towy; characteristic of most Caucasian peoples, but in the eastern Hamites and some others developing long, ringletty curls.

The third basis customarily used in Modern Ethnology is the relative size of the skull. The importance of this measurement is because the relation of mental power to cranial capacity is close. "Casts of the interior of the skull," says Romanes, "show that all the earlier mammals had small brains, with comparatively smooth or unconvoluted surfaces; and that, as time went on, the mammalian brain gradually advanced in size and complexity. Indeed, so small were the cerebral hemispheres of the primitive mammals that they did not overlap the cerebellum, while their smoothness must have been such as in this respect to have resembled the brain of a bird or reptile. This, of course, is just as it ought to be, if the brain, which the skull has to accommodate, has been gradually evolved into larger and larger proportions in respect of its cerebral hemispheres, or the upper masses of it, which constitute the seat of intelligence."

The skull measurement is taken from between the eyebrows to the extreme back of the skull, and the transverse diameter from side to side. The distance from between eyebrows (glabella) to extreme point at back (occiput) being taken at 100, the width of the head is then compared with that, and the proportion stated in percentage terms. The extremes appear to lie between 61.9, a Fijian, and 98.21, a Mongolian, and from 70 to 90 will include all save a few races. Where the width is 75, or under, it is termed Dolichocephalic or Long-Headed; from 75.01 to 77.77, Subdolichocephalic, or ap-

proximating Long-Headedness; from 77.78 to 80, Mesaticephalic, or Medium-Headed; from 80.01 to 83.33, approximating Broad-Headedness; from 83.34 upward, Broad-Headedness.

Thus, among the Long-Headed will come the Kai-Colos of Fiji, 65; the Eskimo, 71.77; the Neanderthal man, 72; the Hottentot and the Bushman, 72.42; West African negro, 73.40; the Arab, 74.06. Among those who approxi-

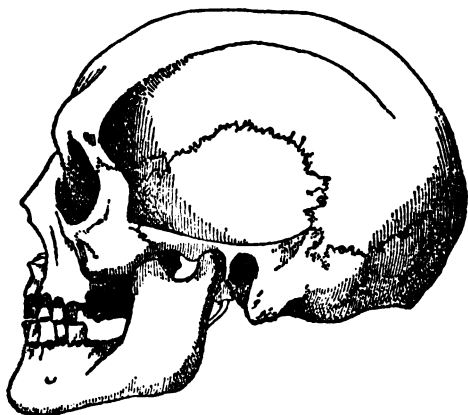


Fig. 14—ORTHOGNATHOUS SKULL OF KALMUK

mate Long-Headedness come the Neolithic men, 75.01; the ancient Egyptians, 75.78; the Anglo-Saxons, 76.10; and the Chinese, 77.60.

Among the Medium-headed are the Ancient Gauls, 78.09; Mexicans, 78.12; the Dutch, 78.89; North Americans, 79.25; Hawaiians, 80. The next division leading to the Broad-Heads contains the Mongols, 81.40; Turks, 81.49; Italians, 81.80; Finns, 82; and South Germans, 83. Then in the Broad-headed races are found the Indo-Chinese, 83.51; Bavarians, 84.87; Lapps, 85.07; Burmese, 86; Armenians, 86.5; Peruvians, 93.

The famous "facial angle," or the means of determining gnathism, is of great importance. Refraining from hyper-detailed statements of the modes of measurement, it may be said that gnathism is the greater or less projection of the upper jaw, which itself depends upon the angle made by the whole face with the brain-cap. Generally speaking, facially it is the projection of the jaw beyond a perpendicular line dropped from the forehead. The divisions between the races are clear and sharp. Thus

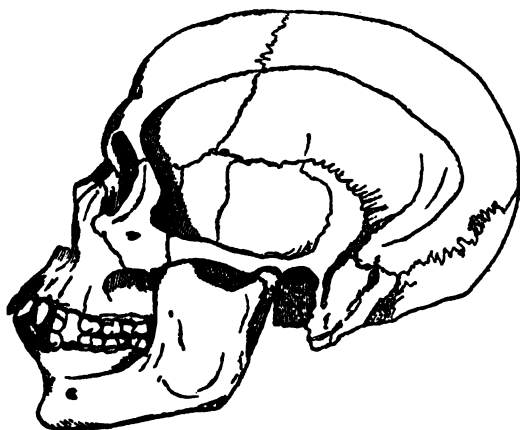


Fig. 15—PROGNATHOUS SKULL OF NEGRO

the white races (pethognathous) range from 89° to 81.30° , the yellow races (mesognathous) from 82° to 76.58° , and the black races (prognathous) from 69° to 59.5° .

Stature is also easily recognised, but it is more variant and the range between individuals of a race is great. Despite this, however, certain distinct classifications do appear and the Patagonian Giants and the African Pigmies occupy opposing ends of the scale. Excluding the abnormal dwarfish and gigantic specimens of the showmen, the height ranges from between 4 feet 7 inches and 6 feet 2

inches with a mean of $5\frac{1}{2}$ feet; this for the male adult, from which for the female must be deducted about 8 per cent. in the tall and 5 per cent. in the short races. Broca and Topinard show that all the Negritos are dwarfish, the true Negroes tall, the Mongols rather below the average, the Americans extremely variable.

The nose also is a well-known characteristic, as the Hebrew illustrates. It may be normally thin, prominent, long, straight or else convex (arched or hooked) in the higher races, in the lower short, broad, more or less concave and even flat. A careful study of this organ shows almost better than any other the coördination of parts in the facial features generally. Thus the small flat concave is usually correlated with high cheek-bones and narrow oblique eyes (Mongol); the short with wide nostrils and depressed root, with everted lips and bombed frontal bone (Negro); the short with blunt rounded base and depressed root, with heavy superciliary ridges and long upper lip (primitive Australian and Tasmanian); the large, straight or arched, with regular oval features (Semite and European).

There is, however, a distinct line between the study of Mankind in races and in peoples, just as there is a distinct difference between the study of Man as the individual and as the race. The study of the individual is what has been called Physical Anthropology, the study of the race has been called Ethnology and the study of a people might well be called Ethnography. Yet Man is always a member of a community and can never be considered without reference to that relation, and it would be a false presentation to show him as an individual and as a race without also depicting his position as a member of an ethnographic group.

CHAPTER IV

THE RACIAL DIVISIONS OF MAN

THE consideration of the physical characteristics and measurements of Man, it will be noted, have brought to light some very striking coincidences with regard to the racial divisions made by anthropologists. Thus, for example, in cranial capacity, in gnathism, in physiognomy, in hair and in many less obtrusive ways it is seen that there is a distinct line of difference between the white race and the black. A man whose color is black, whose hair is blue-black and flat in transverse section, whose jaws are prognathous, whose lips are intumescent, whose nose is broad, flat and with diverging nostrils, and whose teeth are large, cannot be regarded as similar to a man whose color is white, whose hair is flaxen with elliptical section, whose jaws are orthognathous, whose nose is arched or straight with nostrils not diverging, and whose teeth are small. When, in addition to this, the speech, the customs, the religion and the temperant are diametrically opposite, it is clear that these concordances definitely separate one race from another.

When the question is raised, however, as to how many races there are in the human species, it must be admitted that a definitive answer is hard to give. There are certainly three distinct types and probably a fourth, but it seems equally certain that one of these first three is a thoroly mixed race, being based largely on a type that has almost disappeared. The reference is to the Caucasian

race, which carries on many of the characteristics of an Archaean white race, now extinct.

There are two races, however, whose case is simple and clear, the Yellow race or the Mongoloid and the Black race or the Negroid. There has not been any scheme proposed in any age which put these two races together in a classification that has gained even momentary support among scientific men. Whether color, skull, hair, language or customs be brought to bear, these two races remain apart. It is certain, then, that of the human species there are at least two divisions, yellow and black, or Mongoloid and Negroid.

The Caucasian, or the White Race, brings up more difficult questions. Just as the Mongoloid and Negroid are diverse, so is the blue-eyed, flaxen, wavy-haired, ruddy and white complexioned Celt different in almost every particular. But the White Race, as it is often called, is taken to include a wide diversity of types, many of whom are not white at all. Thus, for example, Keane points out that the Black Berbers are Caucasian, and he goes so far as to class the Maoris of New Zealand, the Dyaks of Borneo and the Hawaiian Islanders under a branch of the White Race. With this, tho, present writers cannot agree.

There are certain points, however, even in this complicated matter that seem fairly clear. One is, that the further away from the center of the continent of Europe and Asia the observer goes, the more clearly do the evidences of a white race appear. Thus the nearest possible physical kinship is to be seen between a Celt and an Aino of Japan. Whatever doubt there may be about certain other savage races, there is little doubt with regard to these.

As A. H. Savage Landor has pointed out in his 'Alone with the Hairy Aino,' they possess all the physical characteristics of the Caucasian. Living at the extreme eastern point of the continent, the Ainos are fair in complexion, rarely being as dark even as a southern Frenchman; the eyes have but little coloring pigment, being a light brown

or gray, and are set straight in the head; the nose is finely shaped and slightly arched, and to American and European eyes many of them are quite handsome. Indeed, the older



Fig. 16—AN AINO, THE "WHITE MAN" OF JAPAN

men would in many cases be indistinguishable from an elderly, well-bearded man in America or Europe. The hair is Caucasian in type. The race is by no means pure, and has suffered deterioration by being constantly pushed fur-

ther and further to the edge of the continent, so that their only home now is on a few of the Japanese Islands. The traditions of the Ainos go back to a time when a large portion of the mainland was in their possession.

On the opposite point of the continent, in West Ireland, North Scotland and North Scandinavia, the same type appears, even more pure, for it has not been mixed with Mongol blood. There fair—and even red—hair is to be found, with blue eyes, orthognathous jaw, large cranial capacity and the various other marks distinctive of the Caucasian race. It would appear, therefore, that a white race had once lived in Europe and in Asia, which had been successively pushed further and further out by later peoples, the white strain being less adulterated the further it migrated from the pursuing foe, and keeping much of its purity only upon the very verge of habitable land on the continent. The Caucasian, therefore, is not so much the White Race as a true Caucasian who has made the White Race extinct, but in the doing so has incorporated with himself the various points of the White Race, the mixture being more Archaean white on the edges and more Caucasian in the center.

A Caucasian-Archaean White Race, therefore, is definitely established, and is to be considered as a third branch of the human species, if it is constantly borne in mind that this is a race with a double origin and that many of the apparent discrepancies that occur in it are due to the varying proportions of admixture to be found therein. The so-called Aryan invasion was truly an invasion in every sense of the word, but by a curious mental quirk the existence of the peoples who were invaded have dropped largely out of sight.

A still more difficult question rises, however, when the conditions on the American continent are encountered. Keane declares that "owing to the absence of the higher apes," the New World cannot be regarded as an independent center of evolution for Man himself." The first

part of the statement is true enough, but the conclusion is entirely without warranty, for no one would declare more certainly than Keane himself that Man is not descended from the higher apes. It has been shown that Man in an earlier period diverged from the mammalian stock, but it is not to be forgotten that he is a branch from the mammals, not a twig on a branch from the apes. The distinction is tremendous and vital. It is therefore no argument at all to endeavor to dispose of the origin of the paleolithic and neolithic American races by such a statement.

The archeological importance of America is greatly underestimated. Thus there are good grounds for accepting a Paleolithic Age in Patagonia; there are Neolithic remains widely scattered over the continent; there are irrigation projects in desert New Mexico, once a fertile and well-populated country, irrigation canals made before the lava flowed into them 3,000 years ago; there is a bronze age in Chimu, which was overthrown by the Nahoa invasion—bronze, moreover, of a proportionate alloy found nowhere else in the world; there are the whole group of Aztlan civilizations, of which the later Aztec, Toltec and Maya are still a riddle unread; there are the pueblo tribes, and the whole sealed book of the mound-builders and the makers of the beehive hut.

What is not the least strange of the ideas that have prevailed concerning the American continent and its population is that it must have come from Europe or from Asia. In order to try and bolster up the idea of the dependence of America on Europe for all she had, the old story of the 'lost Atlantis' was revamped and an endeavor made to put the tale on a scientific basis. But the theory was never worthy of the support it gained, and it has now passed to the limbo of archaic beliefs together with the mandrake and the roc.

Scarcely less impossible was the idea that the primitive Americans—that is, the American of paleolithic times—had crossed into this continent from Asia by way of Beh-

ring Straits. At first blush this seems a probable theory, but when the question of glaciation is taken into consideration and it is noted that the ice-cap extended far over the American continent and that the whole of the northeast of Asia and all the northwest of America was an absolutely impassable ice-barrier, the theory loses its appearance of probability. It is to be observed that this does not apply to recent immigrants, to the 'North American Indians'—that is to say, the Hunting Tribes, whose nomadic wanderings extended so widely over the country; they bear no relation to the early settlers—who were not nomads.

Sir Daniel Wilson, an archeologist who has given much attention to American antiquities, declares upon this point: "The Western Hemisphere stands a world apart, with languages and customs essentially its own. To whatever source American man may be referred, his relation to the Old World races are sufficiently remote to preclude any theory of geographical distribution within the historic period." And again: "The studies of the monuments and prehistoric remains of the American continent seem to point conclusively to a native source for its civilization. From quipu to wampum, pictured grave post and buffalo robe to the most finished hieroglyphs of Copan and Palenque, continuous steps appear."

The absolute non-coincidence of American remains is the more remarkable when it is borne in mind that for so many years the endeavor was made to cause every find to be so interpreted as to bolster up the theory of European or Asian origin. Yet Daniel G. Brinton is even more emphatic. "I maintain therefore, in conclusion," he said in a paper read before the International Congress of Anthropology, "that up to the present time (1894) there has not been shown a single dialect, not an art or an institution, not a myth or a religious rite, not a domesticated plant or animal, not a tool, weapon, game or symbol in use in America at the time of the discovery which had been previously

imported from Asia or from any other continent of the Old World."

Upon such a basis, then, it would seem the human species can be grouped into four races—the Negroid, the Mongoloid, the Caucasian and the Americ. The characteristics of the first three are very clearly seen, that of the fourth—if the Hunting Tribes be omitted—is very little known.

It may be objected that there is no sure evidence what was the racial division thousands of years ago. To this P. Topinard, in his 'Anthropology,' may answer. "Whether assisted or not by archeology," he says, "history narrates that, under the Twelfth Dynasty, about 2300 B.C., the

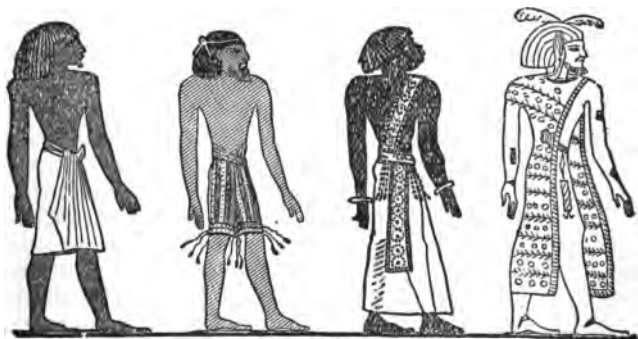
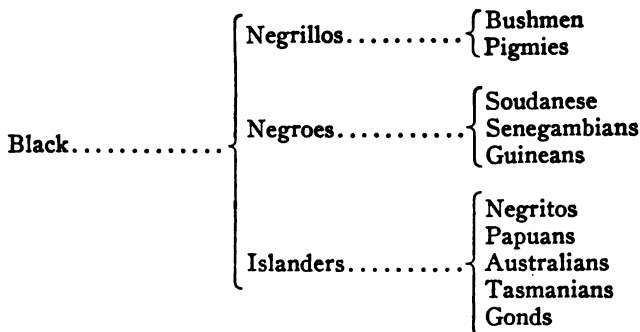


Fig. 17—RACES KNOWN 3,000 YEARS AGO

Egyptians consisted of four races: (1) The 'Rot,' or Egyptians, painted red and similar in feature to the peasants now living on the banks of the Nile; (2) the 'Namahu,' painted yellow, with the aquiline nose, corresponding to the population of Asia to the east of Egypt; (3) the 'Nahsu,' or prognathous negroes, with woolly hair; (4) the 'Tamahu,' whites, with blue eyes."

Thus, taking under consideration the Black Race first,

as it is the most strongly differentiated, a possibly satisfactory division might be made much as follows:



The Negrillo division of the Black Race includes those types of men which present dwarfish characteristics. Of these the two best-known examples are the South African Bushmen and the Pigmies. Both of these are of diminutive stature, the average height being under five feet, and certain stunted tribes showing an average of less than four and a half feet. The skin is very hard and much wrinkled; the nature is ferocious but without persistency; the birth rate is immense, a single child at birth being rare and triplets and quadruplets common; but the death rate is equally large, and longevity is absolutely unknown. They are dull black in color, the ear is small and ape-like, and the arms long.

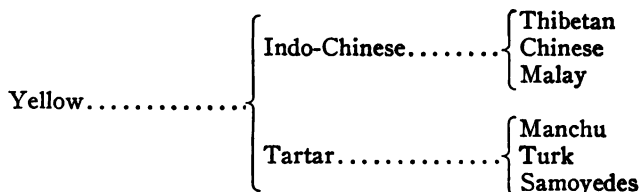
The Negroes proper include those tribes which are found at their best in the upper reaches of the White Nile and about the Nyassas. In contradistinction to the dwarfish Negrillos, they are usually of large stature with a fair muscular frame. They extend from the fine race of the Gabooners in the north to the equally representative Zulus in the extreme south. The Nile tribes, true negroes, are of an intense glossy blackness in color, different entirely

from the sootiness of the Negrillos, and unlike their dwarfish racial co-mates, they are inert and heavy in character, possessing little ferocity or cunning and susceptible of little improvement. The Senegambians, while possessing the essential traits of prognathism, thick lips, receding forehead, coarse but very white teeth and frizzled hair, are slightly less negroid in character; the ramifications of the branch are very extensive, and they alone among the Black Races have given evidence of a possibility of progress. The Guineans comprised the tribes from which the slaves usually were drawn. They are more docile in character, less prognathous in jaw, and their color is less interpenetrative than that of the Nile tribes, but they are none the less distinctly a separate branch of the Black Race.

The Islanders is a loose term embracing a group of tribes, many quite divergent, which are spread over the islands of the South Seas. The Negritos—of whom the Andaman islanders are the best example—are in some measure a mixed race, but are unquestionably negroid. They disclose in especial excess the splay feet characteristic of the Black Race and the protruding heel. The Papuans are probably the root-stock of the two following subdivisions, the Tasmanians and the Australians, and they are a very distinctive type. Indeed, for many years they were classed as a separate race, but this position largely has been abandoned. They are by far the most intelligent of the Islanders and are distinguished very largely by their most characteristic hair, which, throughout all the branches of the division grows very abundantly and very long, possesses a curiously flattened structure and has a peculiarity of separating into tufts of great thickness and strength. The jaws are less prominent than those of the Negroes proper and the lips more shapely. The nose is notably unlike, being long and not too broad. The legs, long and thin, possess a distinct resemblance to those of the Negrillos, tho, of course, on a larger scale. The division of Gonds includes those aboriginal tribes of India

whose presence there is so difficult of explication, but of whose racial characteristics as members of the Black Race there seems good evidence.

A consideration of the Yellow Race might lead to a general division as follows:



The divisions of the Yellow Race are less confused. There are two main divisions, the Indo-Chinese and the Tartar, and between these two the difference is wide. The Yellow Race is characterized by long, straight black hair, which is nearly cylindrical in section, "by a nearly complete absence of beard and hair on the body, by a dark-colored skin, varying from a leather-like yellow to a deep brown or sometimes tending to red, and by prominent cheek-bones, generally accompanied by an oblique setting of the eyes."

Of these the Thibetans seem to represent a fairly pure stock, their isolation having contributed much thereto, and which renders them closely allied to certain of the Malay tribes of the Indo-Chinese group. The Malay is a widely spread branch and has proved one readily susceptible of change. Spreading from the most distant South Sea islands to Madagascar and Ceylon, it has left an imprint on the entire population of Oceanica which, by reason of its division into innumerable islands, had no opportunity to retain homogeneity.

The second great branch of the Indo-Chinese is the Chinese proper. It is greatly subdivided, but is strongly marked by racial as well as national characteristics. Sub-

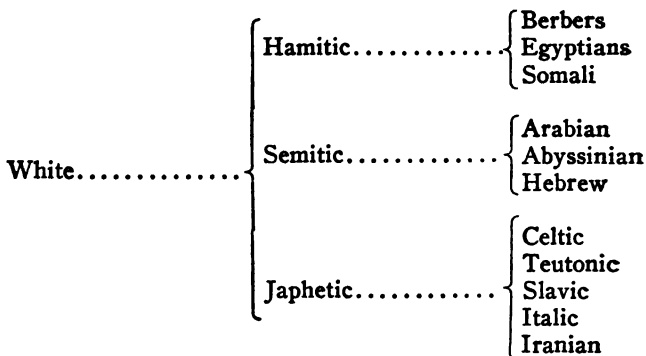
tended by the Malays and Thibetans, it has partaken of the natures of each of these, and provinces in China possess delimitations which have become extremely broad as the result of the density of the population and the scarcity of travel. The intrusion of Tartar blood of the Manchu line (the Manchu is now the reigning dynasty of China) has further complicated the condition of China, so that even the different strata of society in the same province will present problems of intermittent difficulty.

In addition to the Manchu division of the Tartar branch, there is a large group known as the Turks. These are the true dwellers of Turkestan, and there is a strong admixture of this blood in the Beloochis and other tribes on the northern side of the Himalayas; mixed to a certain extent (not great) with Aryan ancestral traits, they form the basic stock for the Turks of the Ottoman Empire. The Cossacks are true Tartars and seem closely allied to the Manchu, with a strong crossing of Turkish heritage. The third group is the Arctic or Samoyedic, a widely spread section of the Tartar race, including Lapps, Finns and in the most divergent example, the Eskimo.

The Yellow Race thus dominates the entire continent of Asia, except Hindostan and Arabia, and besides sweeps half way down through Oceanica. There, in the South Sea archipelagoes, it encounters the Islander branch of the Black Race, which in its turn has covered the entire continent of Africa south of the Sahara and its share of Oceanica. Such a partition, it is evident, is not only ethnological but also ethnographical.

Complex as the inter-tribal relations of the Black and Yellow Races have been, the intermingling of the White Races has been much greater, and consequently the differences between them more slight. In the classification of the White Race that is given below, the old Noachite terms have been used, because, as is well known, the distribution of the White Races does follow in a manner similar to the

traditional wandering of the sons of Noah. It is still popularly held. This classification is as follows:



The Hamitic nations now have fallen to a comparatively unimportant place among the White Races, but in the early days of civilization they were the leading peoples of the world. The Assyrians, the early Egyptians and the Phenicians were all Hamites. The Ionians of the time of Homer belong in the same group and had no small influence on the Hellenes of later dates, and the Etruscans were but little changed from the primal stock.

The Semitic grandeur also has largely disappeared. The Arabs, the Abyssinians and the Hebrews chiefly remain of this once powerful branch, which led all Oriental culture in its Chaldean power. The Elamites and the great conquerors of the Second Assyrian Empire were Semites, but perhaps what has always been the most distinguishing force of this line of the White Races has been its capacity for being absorbed into other peoples, and yet in its very process of absorption Semitizing the alien peoples themselves.

The Japhetic branch of the White Race is that which is dominant to-day. Where lines of divergence are as nar-

row as in the case of this branch of the human family, it avails best to make as clear a subdivision as possible by the old linguistic methods. On such a basis five lines may be cited. Probably the purest and most primitive is the Celtic line, the earliest to diverge, and constantly driven westward, so that it is now confined to the interior and south of Ireland and parts of the west coast; the highlands of Scotland; the mountain fastnesses of Wales and the coasts of Brittany and Normandy, France, speaking the languages respectively of Erse, Gaelic, Welsh, Breton and Armorican. The true type seems to persist in a union of dark hair with light gray and blue eyes and a fair complexion (the flaxen-hair is an Archaean trait). The nature is impulsive, imaginative and chivalrous, but too individualistic to permit of national unity.

The Teutonic peoples are the antithesis of the Celts. Their language has had so formative an effect on all other language used by the White Race, that its limits are vague and ill-defined. The old Maeso-Gothic, the foundation of the German language, was a Teutonic tongue, and high German to-day is the best example of the type. The impress is extremely strong on the English language and the composite Anglo-Saxon is in by far the largest proportion Teutonic. Where the Celt is imaginative the Teuton is solid; the Celtic impulsiveness is opposed by the Teutonic prudence, and wherever this phlegmatic race has abided, self-government and the arts of peace abound. The flaxen-haired, large-limbed Scandinavian is the extreme of the Teutonic type of physical frame, so far, at least, as can now be discerned.

The Italic group is of clear outline. It embraces the nations speaking languages generally known as the "Romance languages," and comprises the nations along the northern shores of the Mediterranean. The military régime of the Roman Empire, which was of Italic stock, wrought a profound effect upon the destinies of southern Europe and stamped its language indelibly upon the

speech of Man. The assimilation by the later Romans of barbarian blood, weakened its permanence as a matter of physical differentiation. The character is passionate, vengeful and pleasure-loving, and by its readiness to consider only the things of the moment, capable of being directed to great deeds by capable leaders. The type is olive-skinned, with dark brown and black eyes and a very glossy hair.

The Slav sphere is of clear contour. The Russian since his first settlement has adopted a policy of exclusiveness to neighboring races and possesses no ability to colonize. His language and customs are strongly individualized and stereotyped and literature is scanty. Tho possessing abilities of a high order, the Slav is notable for a morbidness of temperament and a non-adaptability to progression which has isolated him from the world about him. A rigid class-demarcation, added to this immobility of conditions has led to stratified physical types, but in general it may be said that the Slav is well-built, regular-featured and possessed of an unusually luxuriant growth of hair.

Last comes the Iranian, probably the only branch of the parent stock to deviate from the general westward trend. The Iranians traveled southeasterly and passed over Persia into India. The great Oriental civilizations were theirs, the vast literature of Sanskrit is Iranian, and, moreover, the Iranian imprint upon southern Asia is that which has made it so entirely different in scope and mental attitude from the Asia north of the Himalayas.

On such debatable ground as the origin of races, statements must be cautiously made. Briefly, there are two schools, the one known as 'polygenists' holding that the races of Man were evolved as a result of almost similar conditions in various parts of the globe, and that the causes of this variation are the difference of his origin and of his environment. The other school, the monogenists, hold that Man was descended from a single pair of ancestors, or, it may be, a single group, and that all

the variations of race have been brought about through environment alone. To this latter view may be added the hypothesis that Nature acts 'per saltum,' 'by jumps,' and getting tired of having yellow parents produce yellow children, she varied the program and arranged for one pair to be Negro. Anthropologists are almost evenly divided, tho perhaps the majority may be slightly in favor of monogeny. The present writer holds with the polygenistic school, for the reason that extensive migrations over glaciated areas in glacial times afford too many difficulties; but it is not desired to deal here with a subject calculated to provoke controversy.

The question always will be a difficult one, for the reason that the geological record is not perfect, and the paleontological record of man still less so. Just where the Man left the mammalian stem, and whether it was 'per saltum,' or through gradual process; whether it will be found that all races of Man approach more nearly to a persistent type in the anthropoid ape, or whether certain races of Man will be found more nearly allied to certain different varieties of fossil ape, are questions likely to be long of solution, for the answer may lie deep in some filled-up mountain valley or in the bed of some marine or lacustrine basin.

CHAPTER V

PREHISTORIC ARCHEOLOGY

GREATER libraries than the world has ever dreamed of lie under foot, and scarce a fraction of the treasures of archeology have been exhumed from the strata wherein they lie. All know well the thrill of excitement which pulsates over a community—yes, over the whole world—when a discovery of gold is made, yet such is but a potential treasure for a few men, and is soon spent, while a ‘find’ of true archeological worth is a treasure for all men and all ages to come.

Ruined palaces and fortresses, revealing tales more strange than any fairy story has yet given to the world, hide in the dense forests of Yucatan; cryptic puzzles, as yet unread, clamor for attention to all the world from the highway of Salisbury Plain, England; dim shadowings of the life of the Troglodyte come forth from the caverns of the Dordogne in France; while in every country are to be found the remains of Man side by side with the gigantic animals of an earlier time, bidding moderns seek them and reconstruct the wonders of that ancient age when the ancestors of the present races waged their wonderful war for life.

In every department of human thought the students thereof feel themselves to be working on the subject which is of the chiefest importance and of transcendent interest, but the archeologist affirms as reason for his plea that all these sciences, all these arts, belong to him, and

that the gropings of Man and the development of Man along all lines are but superstructures upon the foundation he is laying. Neither is he confined to race, to period, or to type; if his taste runs to the small detail, he may spend his years deciphering the most minute, semi-obliterated inscription on a stone; or, if he so prefers, he may stand below cyclopean walls and tell the world who made them and how they were erected in their grandeur.

In its truest sense of the word, Prehistoric Archeology is comparatively a new science. For many thousand years men cared little for the history of any save their own country, and even until very recently all history taught in the schools began with Greece and Rome. But the reading of the hieroglyphic inscriptions of Egypt and of Babylon during the last fifty years forced upon the attention of thinking people the fact that history must be vastly more ancient, and to modern views the wars between Athens and Sparta were combats of yesterday.

Linguistic difficulties next arose, and it was pointed out that many centuries must have elapsed before so complete a system as the hieroglyph and the cuneiform were seen to be could have evolved from primitive man. The gradual development of the arts likewise formed a puzzle to the historian, and the date of Man was pushed ever further and further back.

The evolutionary hypothesis, or the Law of Evolution, as it now has a right to be named, of course, was that which changed the whole aspect of history. Instead of Man being a strange creature, made in half a dozen molds by a supernatural hand, and given a higher degree of civilization, from which he afterward fell, it became clear that Man has risen, not fallen. Only a slight knowledge of science was needed to show that the rise would increase in rapidity with later advances, and consequently would decrease in antiquity, so that the earliest faltering steps of Man in any direction must have been slow.

When, therefore, the historian, looking back into the

past, began to compare his earliest dates with the apparent dates of the first appearance of Man upon the earth, he hastily broke company with a 'historian of antiquities,' and gave place to the modern prehistoric archeologist, who presents his science from the actual evidence of tangible objects themselves. Prehistoric anthropologists have investigated these objects and the various deposits containing them as to (1) their human origin, (2) the geologic age of the stratum in which they are found, (3) their original deposit in that stratum at the time it was formed (that is to say, an absence of intrusion or disturbance), (4) the association and superposition of the implements and objects in the stratified deposits; and by the knowledge and experience thus obtained they have determined that man made these objects, and, therefore, he existed in these localities in times of high antiquity.

Prehistoric Archeology deals with three periods, known respectively as the Paleolithic, the Neolithic, and the Bronze Age. They are each distinct from each other, altho the latter two show a certain amount of overlapping that is to be expected. But there is no evidence of a Neolithic race ever having gone back to Paleolithic methods, nor is there a case of a people which has learned to use metal that readily resumed the habitude of stone.

It is unquestionably true that the development of the various races that have been mentioned, the Negroid, the Mongoloid, the Caucasian and the American, followed slightly different channels at widely different speeds, so that the three ages will be found to synchronize in point of time with three peoples who may not be far distant from each other. Thus, it would be absurd to speak of the English at the Battle of Hastings—after such literary works as the 'History of Alfred the Great'—as being Paleolithic or Neolithic Man, yet it is unquestionable

that stone battleaxes were used against the Norman invaders.

The nature of the remains of Primitive Man were collated by Sir John Lubbock (Lord Avebury) in his 'Prehistoric Times,' when he said, "Archeology forms, in fact, the link between geology and history. It is true that in the case of other animals we can, from their bones and teeth, form a definite idea of their habits and mode of life, while in the present state of our knowledge the skeleton of a savage could not always be distinguished from that

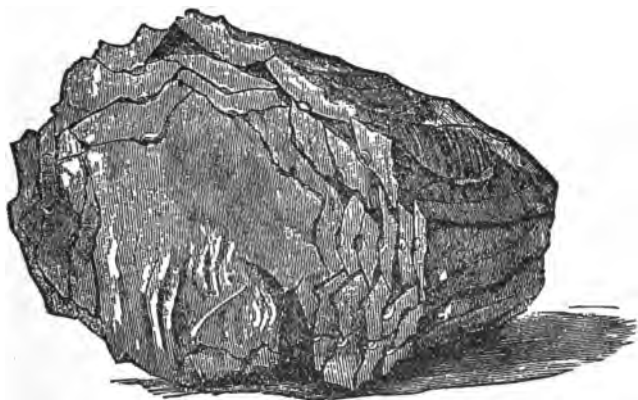


Fig. 18—FLINT KNIVES REPLACED ON BLOCK FROM WHICH THEY HAD BEEN CHIPPED OFF

of a philosopher. But on the other hand, while other animals leave only teeth and bones behind them, the men of past ages are to be studied principally by their works: houses for the living, tombs for the dead, fortifications for defense, temples for worship, implements for use, and ornaments for decoration."

But it will immediately appear evident that all such investigation will depend very largely upon the location in which such finds are made; indeed, it will depend almost

entirely upon such fact. When a flint scraper, however, is found in a river-drift or gravel-bed, which, so far as can be discovered, has never been disturbed, it may be taken as a fair assumption that the scraper and the gravel were laid down together. When, moreover, that same strata contain a great number of such finds, the probability becomes stronger. When, yet again, those scrapers are found close beside the bones of some animal now extinct, but which lived upon the earth at the time that gravel bed was being laid down, the probability becomes assured; and when this juxtaposition is supported by similar finds in similar strata, probability becomes certainty.

Speaking broadly, the materials now available for the study of primitive man are threefold, 'his implements, his monuments, and himself.' The first, from which he rightly takes his name of Paleolithic Man, are in some respects the most important, as being immeasurably the most numerous and widespread, but chiefly because they often occur under conditions which afford the best proof of their artificers' extreme antiquity. The monuments, if such undesigned structures as shell-mounds or kitchen-middens may for convenience be so named, lie necessarily on the surface, or at most on raised beaches, while the fossil remains of man himself have been found almost exclusively amid the general contents, or at most under the stalagmite floors of his cave-dwellings.

If, then, the use of stone for implements was one of the most important lines of useful knowledge possessed by early Man, it becomes important to find out what was the stone so used and the reason for its selection. The two stones most commonly used were jade and flint, and these, accordingly, are found sometimes at long distances from any place where the unworked material could have been secured, showing either that there was some form of commerce in the earliest times, or that the nomadic life of the Paleolithic Man caused him to traverse great distances.

It is remarkable how carefully the best kinds of stone were selected, even when very rare. Of this the most interesting example is afforded by the axes, etc., of Jade or Nephrite, of Jadeite and of Saussurite. These minerals are very distinct chemically, but so similar in appearance that they can only be distinguished by analysis. Objects made from them, tho far from common, are not very rare. Thousands of Jadeite implements and ornaments have been found in Central America, but no deposit has yet been discovered; and, indeed, the jadeite which has been used is of so uniform a texture and chemical composition that it seems as tho all of it had been quarried from the same bed.

Flint was the material most commonly used, but every kind of stone, hard and tough enough for the purpose, was used during the Stone Age in the manufacture of implements, some even harder, but few wherein the lines of cleavage were better adapted. Prehistoric Man valued flint on account of its hardness and mode of fracture, which is such that, with practice, a good sound block can be chipped into almost any form that may be required.

Paleolithic implements abound in the drift gravels; the surface is strewn with flint flakes and fragments of flint implements; and at the present time Grimes Graves is the only place in England where gun-flints are still made. For this purpose one particular layer of flint is found to be well adapted, on account of its hardness and fineness of grain; while another layer, less suitable for gun-flints, is known as "wall-stone," being much used for building purposes.

"It is interesting to find," says Sir John Lubbock, "that even in very early times the merits of the gun-flint layer were well known and appreciated; for altho there is abundance of flint on the surface, the ancient flint-men sank their shafts down past the layer of 'wall-stone,' which occurs at a depth of nineteen and one-half feet,

to the gun-flint layer, which at the spot in question is thirty-nine feet deep."

In one case the roof of a passage had given way. On removing the chalk which had fallen in the end of the gallery came in view. The flint had been hollowed out in three places, and in front of two of these recesses pointing toward the half-excavated stone, were two deer-horn picks, lying just as they had been left, still coated with chalk dust, on which was in one place plainly visible the print of the workman's hand. The tools had evidently been left at the close of a day's work; during the night the gallery had fallen in, and they had never been recovered.

"It was a most impressive sight," says Greenwell, who made the discovery, "and one never to be forgotten, to look, after a lapse, it may be, of 3,000 years, upon a piece of work unfinished, with the tools of the workmen still lying where they had been placed so many centuries ago."

The earliest manifestations of human art consisted of the chipping of implements of flint, practically the first known to have been made or used by man. They belong to the Paleolithic period of the Stone Age. This period has been divided according to progress in human culture, and divers names have been given thereto, following the taste of the writers or discoverers. M. Lartet named the epochs after the animals associated with the implements, and called them, respectively, the epochs of the Cave Bear, the Mammoth, and the Reindeer. M. Dupont, of Belgium, divided it into only two, and named the epochs after the Mammoth and the Reindeer. M. de Mortillet has divided it into five epochs, and has named them, respectively, the Chelléen, after the station of Chelles, a few miles east of Paris; the Acheuléen, after St. Acheul on the river Somme; the Mousterien, after the caverns of Moustier on the river Vézère, Dordogne; the Solutréen, after the rock shelter of Solutré near Macon;

and the Madelainien, after the rock shelter of La Madeleine, Dordogne.

The peculiar characteristic of the implements of the Paleolithic period is that man's cutting implements, usu-

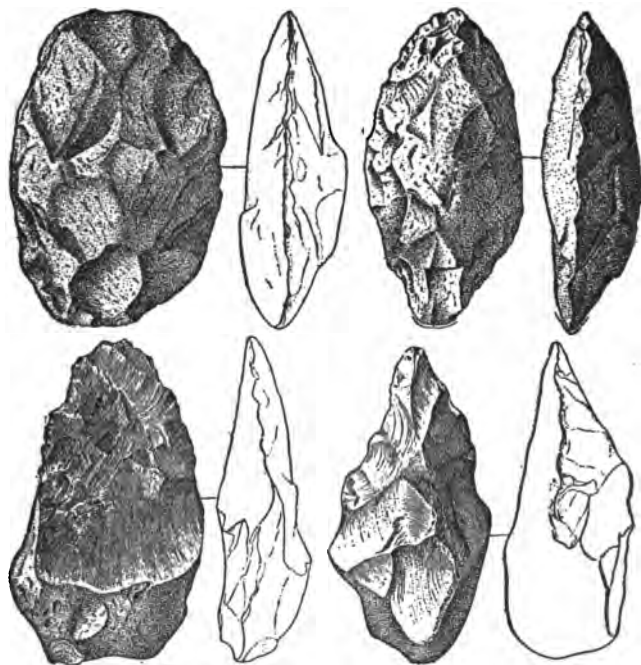


Fig. 19—EARLIEST STONE IMPLEMENTS—(Chelléen).

Chipped flakes of quartzite from India and Africa; of flint from France and England.

ally of stone, preferably flint, were made by chipping. In the later epochs of the Paleolithic period certain implements were made of bone and horn, which were ground or smoothed, while those of stone were not. It is not,

however, to be supposed that every chipped stone implement belonged to the Paleolithic period, for the prehistoric man of the Neolithic period chipped many implements of stone. Yet E. B. Tylor, in his 'Anahuac,' points out that

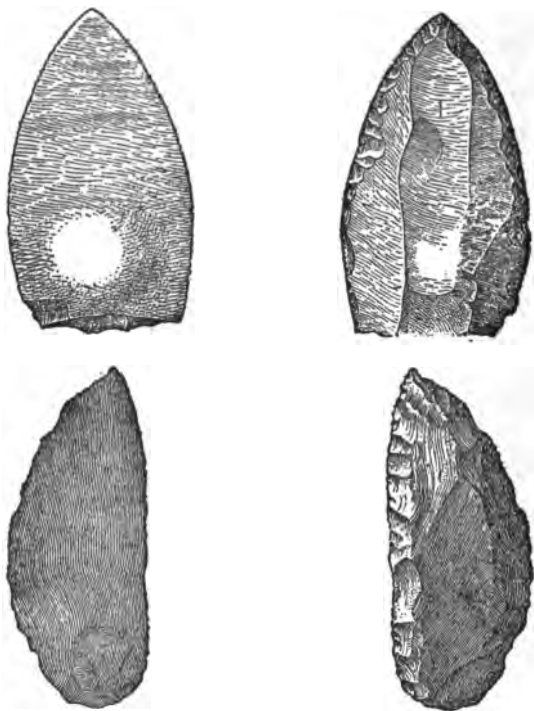


Fig. 20—AMERICAN FLINT IMPLEMENTS—(Mousterien).

force was probably also used and describes a process he saw in operation on flakes of obsidian.

The flint implements of the Chelléen period are, as is to be expected, extremely rough, and those that are shown

are presented with both front and side views to emphasize the difference between them and the thinner implements which followed. Oval in shape, they possess a distinct cutting edge at the point, and the general shape was that of a plum stone, a few being of a sharper curve like an almond. It is not to be supposed that these were determined differences, but rather were dependent upon the nature of the original fracture.

But implements of this character are found widely spread, altho—and this is worthy of profound attention—they are not found in northern countries which were under the ice-cap. In the United States, while it cannot be stated that their nature is such as to demand precisely the same conclusions that have been reached in Europe, yet Thomas Wilson, in his 'Prehistoric Art,' seems justified in saying: "It is apparent on slight inspection that these implements found in the United States, altho mostly on the surface, are of the same Paleolithic type as those found in the gravels of Europe and elsewhere."

The Cavern Period, as following upon the Drift, shows a distinct advance. "It appears certain," says Wilson, "that there was at the beginning of this epoch a material change in human art and industry. The Chelléen and St. Acheuléen implements, so widespread, were superseded by objects now found in the caves and rock shelters occupied by man. This statement might be doubted if it rested on a few objects, but its truth will be apparent when we consider that these implements have been found throughout western Europe by hundreds of seekers, in thousands of places, and to the number of tens of thousands, but 'never associated' with 'cave implements' or objects; while on the other hand, tens of thousands of cavern implements and objects have been found in their appropriate places and never associated 'with Chelléen or St. Acheuléen implements.' I say 'never'—if any have been thus

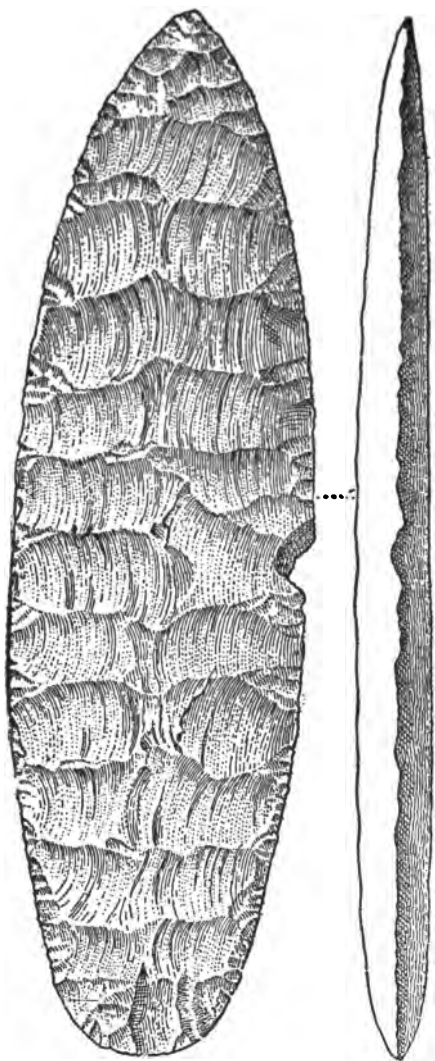


Fig. 21.—HIGHEST TYPE OF AMERICAN FLINT CHIPPING—(Solutrén).

found, the proportion is insignificant, not one in a hundred, so that the statement is substantially true."

The art of flint chipping has never, in prehistoric times, nor among prehistoric or savage peoples, attained a higher degree of excellence than during the Solutréen epoch. There seems to have been an evolution from the rude and heavy Chelléen implements up to the fine Solutréen leaf-shaped blades. What time elapsed between the two there is no means of determining; it is to be counted by geologic epochs, and not by years or centuries. There was a regular and steady improvement in the art of flint chipping, produced, apparently, by continued experiment and practice, the result of which must have been communicated or transmitted from father to son, from teacher to student, from master to apprentice, until the ideal flint chipping was attained in the Solutréen leaf-shaped blades.

From chipped stone to polished stone does not seem so great a change, yet between the paleolithic and the neolithic period is a wide, unbridged gap. The wild, hairy savage of Paleolithic times, with a marked difference even in shape of skull, was a man with an ideal, with a sense of beauty, with a desire not only to make those things which he knew he needed, but even to decorate them. From the rude flint flake to the carving on the reindeer horn (to be dealt with in Prehistoric Art) is a long step, yet this step paleolithic man took, and his progress can be traced along every inch of the way.

But Neolithic Man was a widely different being. True, he followed the use of the flint implement, but he carried it to a higher perfection. He adopted a local habitation and a permanent place of residence, he became an agriculturist as well as a hunter and fisher, and he buried his dead as though expectant of a life to come. He built houses and erected wonderful megalithic monuments, and at the last discovered the art of smelting metals, and with Bronze weapons and ornaments ushered in the Age of Iron.

The great characterization of the Neolithic period is the wonderful change in ornamentation, the drawings of the later paleolithic period giving place to mere geometrical designs, and the polishing of the flints after they

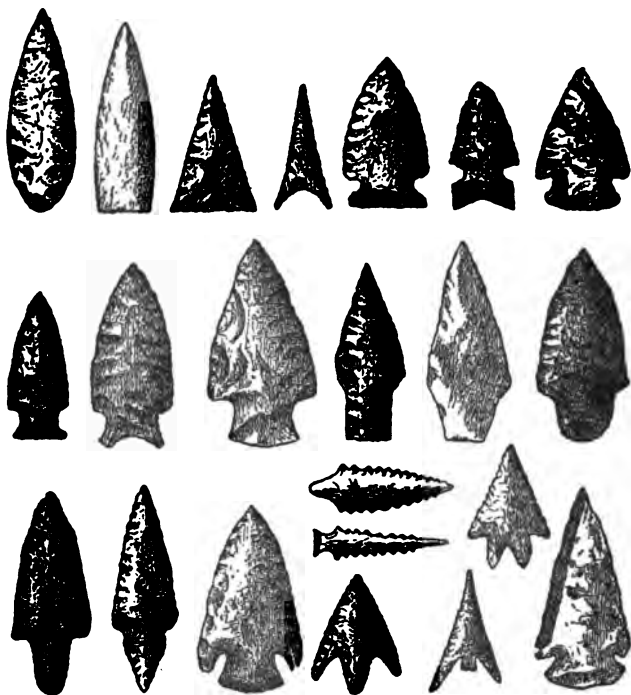


Fig. 22—AMERICAN NEOLITHIC FLINT SPEAR AND ARROW HEADS

had been chipped, and the greater skill and marked care shown.

After the flint flakes, used for many purposes, principally as knives, perhaps the next in importance are the axes or celts. There are many forms of these celts and

these flakes, which have been called chisels, scrapers, axes, adzes, and so forth, but the next true departure is the spear-head.

These spear-heads are often of great delicacy of make, so fine, indeed, that they have not been duplicated by any modern attempts. The larger scrapers can be easily made, but the manual dexterity required for the making of a long, thin, evenly beveled spear-head, and the time and patience demanded, are not to be found to-day. As has been wisely said, let any one who does not appreciate the value of these flint implements in determining the location of Man try and make one of them, and he will find it to be a task of considerable difficulty.

Of even more interest are the megalithic monuments of prehistoric man. In every country that has been in any sense investigated, the remnants of strange constructions of prehistoric times remain. Whether it be the circle at Stonehenge, or the mounds of Ohio, whether it be the monuments in the desert near Mount Sinai or the huge stones of Peru, whether it be the pyramids of Mexico or of Egypt, the dolmens of Scotland or the menhirs of Ireland, everywhere they are encountered.

England is full of them and the riches of the American prehistoric period are only barely touched. "In our own island," says Sir John Lubbock, "the smaller tumuli may be seen on every down; in the Orkneys alone it is estimated that 2,000 still remain. On the Wiltshire Downs there are over 1,000, in France there are 4,000 dolmens, 1,600 menhirs, and 450 stone circles; in Denmark they are even more abundant; they are found all over Europe, from the shores of the Atlantic to the Ural Mountains; in Asia they are scattered over the great steppes from the borders of Russia to the Pacific Ocean, and from the plains of Siberia to those of Hindostan; the entire plain of Jelalabad being literally covered with tumuli and monuments. In America we are told that they are num-

bered by thousands and tens of thousands; nor are they wanting in Africa."

The stone circle is usually a ring of upright stone surrounding a mound. Often, however, it is on a level piece



Fig. 23—DOLMENS FROM EUROPE AND ASIA

Showing similarity of structure the world over. Upper stones from Kent, England; lower, from Dekkan, India.

of ground and has an avenue of menhirs leading up to it. The most famous of them all is Stonehenge in England. There were thirty rudely hewn pillars from four to eight



THE GREAT CIRCLE AT STONEHENGE.

feet wide, two to four feet thick, and sixteen feet high above the ground, and about three or four feet apart, forming a circle a hundred feet in diameter. Each of these pillars had on its top two tenons which rested in mortice holes cut in a stone architrave connecting each pair of pillars. Most of the posts and architraves have fallen to the ground, but enough remain to show clearly the size and pattern of the structure. An inner circle of stones had ten posts in five pairs, each pair being about ten feet from the one on either side. The material of these posts and architraves is sandstone found in the vicinity; but inside of the second circle there is a third small circle with posts of a blue igneous rock, which is supposed to have been brought from Ireland. The largest of these is seven feet long, two feet wide and a foot thick. A large flat stone in the center of the circle is supposed to have served as an altar.

It is an inexpressible pity that one of the finest megalithic monuments in the world should have been despoiled. Of the great temple at Avebury, in Wiltshire, England, it has been said by one of its admirers that "it did as much exceed Stonehenge, as a cathedral a parish church." Once 650 great stones, forming a vast circle around an artificial hill, and led up to by two avenues of menhirs half a mile long, stood upon the plain, but the little village of Avebury has been built upon and of the hill, the great megaliths have been broken up for building stone, and of the great ruin, only twenty stones are still standing.

Great as are the works of prehistoric man in Britannia, Gaul and Mauritania, they are rivaled by those of prehistoric man in the New World. "South of the barbaric mound-builders of the Mississippi basin," says A. H. Keane in his 'Ethnology,' "follow in almost unbroken succession the Casas Grandes of the Pueblo Indians, New Mexico and Arizona; the truncated pyramids and other remains of the Toltecs and their Nahua successors on the Anahuac Tableland; the palace of Mitla, South Mex-

ico, of classic beauty; the elaborately ornamented temples, palaces, convents, raised by the Mayas of Palenque, Uxmal, Chichen-Itza and other cities of Yucatan; the great temples of the sun, the causeways, aqueducts and terraced slopes of the Peruvian Quichuas. Some of these



Fig. 24—MENHIR IN BRITTANY, FRANCE, 36½ FEET HIGH

are prehistoric, while others reach well into the historic period. But none can compare in magnitude and exquisite finish with the stupendous megalithic edifices of doubtful origin, which stand in an almost uninhabitable region near the southern shores of Lake Titicaca on the Bolivian plateau, nearly 13,000 feet above sea-level.

Altho often visited and partly described, full justice has only quite recently been done to these astounding ruins of Tiahuanaco by Stübel and Uhle, who have devoted a sumptuous volume to their description and illustration. The monuments, which cover a large area between the lake and Pumapunga, tho chiefly centered about the Ak-Kapana hill, here shown to be a natural formation, not an artificial mound, are of an absolutely unique character, despite certain general resemblances to the neolithic structures of the eastern hemisphere. As shown by the numerous highly polished slabs and blocks lying flat on the ground, as if ready for the mason, it is evident that all formed part of a general design on a scale rivaling that of the largest Egyptian temples, but never completed, the works having apparently been interrupted by the Inca conquerors. They must have been in progress for some generations before that time, for the blocks, some weighing from 100 to 150 tons, had been conveyed with primitive appliances from distances of many miles over rugged ground, up steep inclines, and in some cases across several inlets of Lake Titicaca.

It is notable that certain of the stones, like those of Stonehenge, have shoulders for the reception of horizontal connecting beams, but far better dressed and mortised. Others form doorways hewn in a single piece, one of which at Ak-Kapana is the crowning triumph of the primitive American architecture. This marvelous monolith, weighing over twelve tons, is richly carved on one face with symbolic devices and the image of Viracocha, tutelar deity of the Bolivian Aymaras, overthrown by the Quichua worshipers of the rival Peruvian sun-god. Nor can mention be omitted of the stupendous earth-works of the Mound-Builders, whose very origin is so obscure. Widespread as are megalithic monuments in the Old World, these mounds are even more numerous in the New. The number of them catalogued runs into hundreds of thousands, and they are found as forts, as temples, as observation points; in the

forms of animals, birds and human figures; of regular geometrical forms and of shapes the very purpose of which is unknown; of several different styles of construction,

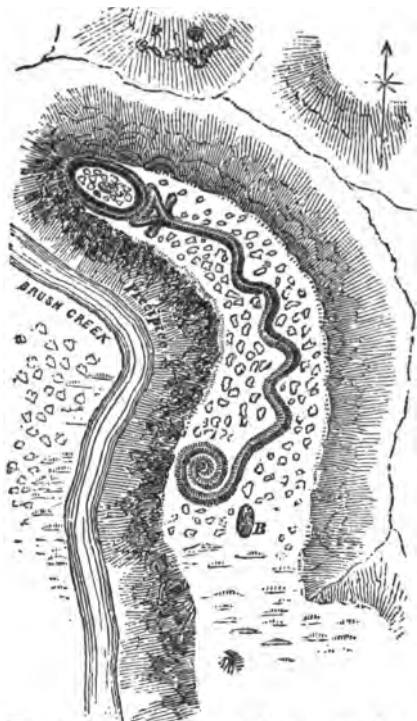


Fig. 25—GREAT SERPENT MOUND OF OHIO

Earthwork 700 ft. long; 1,000 ft. extended; base, 30 ft. broad; height, 5 ft., tapering; oval, 160 x 80 ft.; on edge of sheer cliff 150 ft. above creek.

presuming the existence of an extensive civilization over the entire United States.

“Lacustrine or marine settlements form an interesting

feature in the evolution of human progress," points out A. H. Keane in his 'Ethnology,' "their development being intimately dependent on the local conditions at certain stages of culture. Communities seated by the shores of lakes or shallow inland seas possess obvious advantages over tribes confined to the woodlands or the plains. They draw their supplies both from land and water, and to their other resources are added navigation followed by barter and piracy. But on the other hand, the wealth thus rapidly accumulated exposes them to the attacks of predatory hordes, to guard against which they take refuge in their boats. They are thus gradually transformed to a floating population, which soon learns to adapt itself to the new environment by erecting dwellings on platforms resting on piles driven into the mud or sands of a shelving beach. Then, when peaceful days and orderly government take the place of lawless habits, a return is made to terra firma, and the abandoned lacustrine dwellings soon disappear; but the sites remain the safe depositories of the multifarious objects of human industry which have accumulated beneath the shallow waters during their occupation."

Such is the history, either completed or still in progress, of the numerous floating habitations which are found in every part of the world from the New Guinea coastlands and the estuaries of the Borneo rivers to Helvetia and the British Isles, and beyond the Atlantic to the aquatic settlements of the Maracaibo Sea, to which the surrounding region owes its present name of Venezuela, "Little Venice." Such especially is the history of the Swiss lake-dwellings, the recent exploration of which has shown them to be one of the richest storehouses of neolithic and prehistoric industries. Antiquaries have already explored over two hundred of such stations, some of which were occupied again and again, like Hissarlik (Troy), Lachish, and those other eastern cities, where the vestiges of several distinct civilizations are found superimposed one on the other.

At Robenhausen, south side of Lake Pfäffikon, three such prehistoric occupations have been disclosed, each destroyed before the next began, as shown by the three sets of piles (100,000 altogether), each projecting from 3 to 5 feet higher than the one below. So also at Morges, on the north side of Lake Geneva, there were three different stations, here, however, not superimposed, but standing in close proximity within a space of about a third of a mile. Nevertheless, they were not inhabited simultaneously, but successively, as shown by their relics, all stone in the earliest, stone and rude bronze hatchets in the next, bronze alone and very fine bronze in the last, the great prehistoric city of Morges. Even the present Morges appears to be some 1,200 or 1,500 years old; yet it never had any record or memory of its predecessor till its existence was revealed in 1854 by the subsidence of the lake, due to an exceptionally long drought.

The Bronze Age is one of the most unsettled periods in Archeology. It is clear, of course, that it follows the Neolithic Age in general and that it preceded the Age of Iron, but it by no means is clear that it was not in many cases synchronous with the later Neolithic. Every find of bronze as weapons and implements has been made in connection with Neolithic remains and there is no instance of a long continuance of the use of bronze after the knowledge of iron. But the use of bronze as ornamental purposes continued well on into historic times, and indeed it cannot be said to be entirely abolished to-day.

"Many objects of wrought copper have been found in America," says Thos. Wilson. "The Lake Superior copper mines in the States of Wisconsin and Michigan appear to have been the center of manufacture, from which the distribution took place, and thence the manufactured implements spread, in gradually decreasing numbers, in every direction throughout the present territory of the eastern United States. The modes of treating copper, whether by smelting, melting, casting or hammering, and if any or all

of these, what amount of heating or melting was done, has never been fully investigated nor have they been satisfactorily determined. Some of the objects were certainly of virgin copper hammered cold, and they were thus made

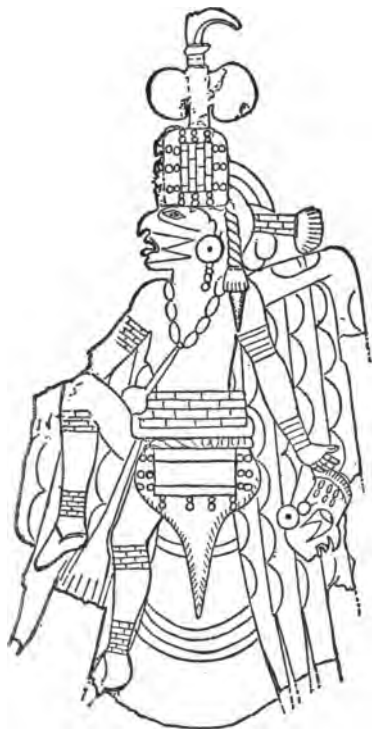


Fig. 26—HUMAN FIGURE OF REPOUSSÉ COPPER MADE BY GEORGIA MOUND-BUILDERS (U. S. N. M.)

into bracelets, rings, and similar objects of personal adornment, and also into axes, knives, and spearheads. These copper weapons and ornaments continued to be used con-

temporaneously with cutting implements of stone and of ornaments of shell and bone.

"Among the many mysteries of prehistoric archeology growing out of mound excavation in the United States, wherein things strange and wonderful but of undoubted genuineness and antiquity are found, none are more unexplained than the thin sheets of copper wrought by repoussé work into curious and unknown devices found in mounds and earthworks in widely separated regions of the country. The principal specimens come from the Tumlin mounds on the Etowah River, near Cartersville, Ga., but Ohio and Illinois mounds also have furnished examples."

By such steps as these, therefore, can be roughly traced the development of Man from his earliest ancestor as Man down to the Historic period. How many years elapsed between the period of 'Homo Primigenius' and the first flint-flake there is no means of determining, neither can it be said whether it was in hundreds, thousands or tens of thousands of years. It is now thought improbable, however, that Man's ancestor in the Tertiary Epoch could rightly be called Man, but it is obvious that the date of the beginning of the Quaternary would be extremely difficult to estimate, even approximately.

His life was largely influenced by his weapons and his tools, and they again reflect to his successor the life he led. By their means, therefore, it becomes possible in a measure to reconstruct the life of Primitive Man and to shadow forth the development of that more subtle force called culture. Anthropology has detailed what Man is and the conditions of his physical frame, Ethnology has set forth his racial division and specific unity, Ethnography has pointed out his distribution, and Archeology has collated and classified the evidences of his early being; it remains therefore to bring all these together under a consideration of the development of culture, that perhaps a vague outline of the philosophy of primeval history may come into view.

CHAPTER VI

THE DEVELOPMENT OF CULTURE

To THE development of Man as an individual and as a race must be added his advance as a producer of that which is called Civilization. For it is the especial prerogative of Man to be the ruler of his environment, not the slave of it, and whereas the effect of the animal upon the environment is always purely unconscious, the influence of Man is purposeful. He is not content with taking Nature as he finds her, but has the audacity and the power to utilize her forces and even to divert them.

It is of course abundantly clear that such a daring flight of thought never occurred as such to Primitive Man, nay rather, that he conceived Nature as being a supernatural or a group of supernaturals; but none the less, even at such a time, he conceived the idea of influencing those supernatural personified forces by worship, sacrifice and so forth. It is one of the essential characteristics of Man that he is conscious of his power and seems inwardly to believe with the Ancient Pistol, "The world is mine oyster, which I with mine sword will open."

That the human embryo passes through the various stages of the mammalian stem prior to the branching forth of Man has been abundantly shown, and indeed now is not to be questioned, and it is equally true that the development of the mind of the child during childhood follows closely upon the scale of mental faculties possessed by the lower animals, paralleling them in nearly all details. The

emotional faculties of the child, moreover, can scarcely be distinguished from those belonging to the simpler orders of animal life.

If the history of the individual be used as a comparison for the history of Mankind, precisely the same condition will be seen to appear. In the earliest times of Man his mental condition was not different from that of the creatures around him, but he possessed the capacity for greater progress and higher advancement than they. The very flint instruments that have been considered tell the same story, passing from the rudest flakes of the Chelleen division of the Paleolithic period to the most polished specimens of the Neolithic Age just ere bronze changed the conditions of Man and led to the way to a further civilization. Likewise in shelters, from the rude sticks covered with the skins of animals and heaps of rough piled stones to the wonders of the Parthenon is not one mighty stride born from an inspiration, but a long, slow, careful process, each improvement building upon the last. And whether such a comparison be carried out into the mind of thought, from fetichism to the Brahma of the Vedas and the God of Isaiah, from guttural stammerings to the oratory of Demosthenes and the literature of Goethe, from the use of the wife as a beast of burden to the modern railroad, all alike tell the same story of progress starting from the humblest beginnings, the same triumphal march of evolution.

It seems wise to point out at this place that the Development of Culture is not to be regarded as the steps that have been taken from imperfection to perfection, but as the advance from imperfection to a slightly less imperfection. The human mind at present is not formed, but only forming, and there are heights illimitable yet to be climbed. By slow and dubious steps, groping wearily in the dark, the ancestors whose lives are learned only from their flint remains, climbed to simple consciousness. Self-consciousness—a far higher concept—was not reached probably for,

thousands of years later, and unconscious self-consciousness, paradox tho it seem, is one of the avenues along which it is seen that the mind of Man is tending.

But it would be a heinous mistake to suppose that "surely we are the people and wisdom will die with us," for it is as affirmed as any scientific fact can be that Evolution is an invincible force not to be stopped by any human agency. It has always gone on, it still is going on, and so far as can presently be seen, it always will go on. Some of the old mental faculties are dying out and others taking their place, not with any degree of uniformity, but in such wise that looking back over a vista of centuries it can be seen that there has been a distinct advance. There have been losses also, but the general direction has been upward. Whether the present gropings for relations to a super-sensual sphere, such as telepathy and clairvoyance, are vague shadowings of future lines of development or merely temporary phases of thought is yet to be seen, but it is certain that they cannot be overlooked in any consideration of the probable development of the future.

A long distance has been traversed, how great a distance is best seen by comparing the percept of the savage and probably of primitive man with the concept of the best developed mind. Suppose the word 'star' be taken as a case in point. The recognition of one particular star is a simple idea or percept, the recognition of a number of stars, or of bright, twinkling objects resembling the shining of stars, is a complex idea or recept. So far the mind of the higher brutes keeps pace with the developing mind of man. But the next step carries us beyond the mental powers both of infants and of animals; neither can conceive the idea of a star as present to the mind of an astronomer. This is an abstract idea or concept, and is unattainable except through the medium of articulate language. Where the child sees a twinkling spark the astronomer is conscious of a flaming sun; where, until lately, men recognised the symbol of unchangeableness,

the astronomer knows he beholds stupendous worlds rushing through space at unimaginable speed; where the Hebrew seer beheld "lesser lights" stuck in a solid firmament solely for the service of man, the astronomer knows that his eye beholds objects at a distance of millions upon millions of miles, objects whose grandeur throws our whole solar system into insignificance. An abstract idea is in itself capable of containing a volume of knowledge; its capacities have hardly any limits but that of the mind itself.

Thus upon the character of the traditional material lies the chief line of difference in the results of thought. Herein lies the immense importance of folklore. Herein also lies particularly the enormous influence of current philosophic opinion upon the masses of the people, and herein lies the influence of the dominant scientific theory upon the character of scientific work. It would be in vain to try to understand the development of modern science without an intelligent understanding of modern philosophy; it would be in vain to try to understand the history of medieval science without an intelligent knowledge of medieval theology; and so it is in vain to try to understand primitive science without an intelligent knowledge of primitive mythology. Mythology, theology and philosophy are different terms for the same influences which shape the current of human thought and which determine the character of the attempts of man to explain the phenomena of Nature.

The influence of traditional material upon the life of man is not restricted to his thoughts, but manifests itself no less in his activities. The comparison between civilized man and primitive man in this respect is even more instructive than in the preceding case. A comparison between the modes of life of different nations, and particularly of civilized man and of primitive man, makes it clear that an enormous number of actions are determined entirely by traditional associations.

"When we consider," said John Evans before the Anthropological Society of England, "for instance, the whole range of our daily life, we notice how strictly we are dependent upon tradition that cannot be accounted for by any logical reasoning. We eat our three meals every day, and feel unhappy if we have to forego one of them. There is no physiological reason which demands three meals a day, and we find that many people are satisfied with two meals, while others enjoy four or even more. The range of animals and plants which we utilize for food is limited, and we have a decided aversion against eating dogs, or horses, or cats. There is certainly no objective reason for such aversion, since a great many people consider dogs and horses as dainties.

"When we consider fashions, the same becomes still more apparent. To appear in the fashions of our forefathers of two centuries ago would be entirely out of the question and would expose one to ridicule. The whole range of actions that are considered as proper and improper cannot be explained by any logical reason, but are almost all entirely due to custom; that is to say, they are purely traditional. This is even true of customs which excite strong emotions, as, for instance, those produced by infractions of modesty."

It will be obvious to the reader that the modern viewpoint of Culture is that it has developed, not that it is the remains of something still higher which has been gradually lost. The religious dogma of the Fall of Man under medieval theology came to be applied to more than the moral aspect, with the sad result that a conception arose which depicted Adam and Eve as possessing all knowledge, and their descendants as continually falling away therefrom. Even in the nineteenth century, in his "Soirees de St. Petersburg," Count Joseph de Maistre wrote: "We separate ourselves always from that banal hypothesis that Man had gradually elevated himself from a condition of barbarism to an understanding of science and to civili-

zation. This is the fondest dream, the mother-error, and as it is taught in the schools, underlying falsity of our age." He goes on to speak of the "philosophers of this unhappy age, who, with the horrible perversity that we have seen in them, persist in their errors in spite of the warnings they have received," and decline to follow the Count's lead in the degeneration theory.

But progression in culture, while universally conceded at the present time, is by no means a new theory. Even the historian Gibbon, in his 'Decline and Fall of the Roman Empire,' perceived that by no other conception save that of progression could the events of history be read intelligently. "The discoveries of ancient and modern navigators," he said, "and the domestic history of tradition of the most enlightened nations, represent the human savage naked both in mind and body, and destitute of laws, of arts, of ideas and almost of language. From this abject condition, perhaps the primitive and universal state of Man, he has gradually arisen to command the animals, to fertilize the earth, to traverse the ocean and to measure the heavens. His progress in the improvement and exercise of his mental and corporeal faculties has been irregular and various. Infinitely slow in the beginning and increasing by degrees with redoubled velocity, ages of laborious ascent have been followed by a moment of rapid downfall; and the several climates of the globe have felt the vicissitudes of light and darkness.

"Yet the experience of four thousand years should enlarge our hopes and diminish our apprehensions; we cannot determine to what height the human species may aspire in their advances toward perfection; but it may safely be presumed that no people, unless the face of nature is changed, will relapse into their original barbarism. We may therefore acquiesce in the pleasing conclusion, that every age of the world has increased, and still increases, the real wealth, the happiness, the knowledge, and perhaps the virtue of the human race."

That two such diverse points of view should have had many wise supporters leads to the conclusion that there must be something that is true in each. "Of course," says E. B. Tylor in his 'Primitive Culture,' "the progression theory recognises degradation, and the degradation theory recognises progression as powerful influences in the course of Culture. Under proper limitations the principles of both theories are conformable to historical knowledge, which shows us, on the one hand, that the state of the higher nations was reached by progression from a lower state, and, on the other hand, that culture gained by progression may be lost by degradation. If in this inquiry we should be obliged to end in the dark, at any rate we need not begin there."

The famous argument adduced by Niebuhr against the progressionists that "no single example can be brought forward of an actually savage people having independently become civilized," seems to possess a great deal of strength until it is pointed out that the obverse of the same question may well be put to the degradationists, in the following form: No single example can be brought forward of an actually civilized people having independently become savage. There are things which lend themselves 'prima facie' to support, and others that do not, and the idea, for instance, that a tribe which had learned the production of fire by a drill should willingly go back to the more toilsome method of rubbing two sticks together belongs to the latter class.

But Sir Charles Lyell, with the vein of sarcasm he knew so well to use—sometimes disastrously—deals with the degradation theory in such wise as to settle it in a few sentences. Speaking of the progressive nature of the finds in earlier geological deposits, and contrasting the actual evidence with the imagined hypothesis, he says, "Instead of the rudest pottery or flint tools, so irregular in form as to cause the unpracticed eye to doubt whether they afford unmistakable evidence of design, should we not be finding

sculptured forms surpassing in beauty the masterpieces of Phidias or Praxiteles; lines of buried railway and electric telegraphs, from which the best engineers of our day might gain invaluable hints; astronomical instruments and microscopes of more advanced construction than any known in Europe, and other indications of perfection in the arts and sciences, such as the nineteenth century has not yet witnessed? Still farther would the triumphs of inventive genius be found to have been carried, when the later deposits, now assigned to the ages of bronze and iron, were formed. Vainly should we be straining our imagination to guess the possible uses and meanings of such relics—machines, perhaps for navigating the air or exploring the depths of the ocean, or for calculating arithmetical problems beyond the wants or even the conceptions of living mathematicians."

It may be assumed as proved, therefore, that Culture is to be regarded as a matter of development, rather than as a matter of deterioration, and that all the study of Pre-historic and of Historic Man is to be regarded as an appanage of a study of Culture. In a preface to a work, 'History of the Mental Growth of Mankind in Ancient Times,' John S. Hittell has propounded a series of questions, the answers to which would cover the whole history of the development of Culture. It is most suggestive, if only to show the immensity of the field the student of Culture must endeavor to cover.

When the question arises as to the divisions in the development of culture, Hittell makes a triple culture step, Savagism, Barbarism and Civilization. The division is arbitrary, of course, and the nations that he places in each division will not secure general agreement, and it would seem perhaps more convenient to add a fourth, splitting in twain his division of Barbarism. In the division of Savagism can certainly be placed the entire Negroid Race, for it cannot be said that any single tribe of the black race—and this is a sufficiently remarkable fact—have ever

reached Barbarism, much less Civilization. Uncultured they have been ever, and it appears probable that ignorant they will ever remain. Hybrids of negro and white may continue and flourish, nurtured under a non-indigenous hothouse condition of civilization they may prosper, but the Black Republic and the Negro Empire of Haiti answer all questions as to the fate of negroes, after they have been taught, being left to their own devices. The Negroid, living in Negroid environment, so far as can be found out, has made no step toward true civilization.

There is probably some little arrogance in making a distinction between types of Civilization and making a separate class of them, but none the less a word is needed to express the races which advanced to a certain point, and then, for many reasons, suffered an arrest of development. The Chinese, for example, cannot be called a barbarous race, as Hittell has done, for their civilization is equally well grounded with the Caucasian. But it has not reached as far, and it does not seem to be progressing, insomuch that they are always cited as an example of arrested development. Of a far lower order are the Nahua and Aztlan civilizations in America. It might be well, therefore, to class such nations as the Chinese under 'Arrested Civilizations' as contrasted with 'Progressive Civilizations,' it being understood that no stigma attaches thereto. The Archæan White race also would come under this class.

Barbarism is certainly the condition of the primitive American races. They had only recently arisen from the stone age, and despite the wonderful works that they had succeeded in doing, their only tools were of bronze. It is laying a little too much stress on bronze, perhaps, to make this the cause for a culture-division, but in the case of the American Primitive Races, this was coupled to customs purely barbaric, such as human sacrifices and cannibalism.

For example, it is stated that "the most common method of sacrifice among the Aztecs was that the person was

laid with his back upon a convex stone, and while his legs, arms and head were held by five priests, another cut open his breast, and took out his heart, held it up to the sun, rubbed the lips of the idol with it and then threw it into a basin which stood on the altar. If the victim was a prisoner of war, the corpse was thrown from the top of the temple pyramid, where it was picked up by the owner, the captor, who took it to his house to be cooked and eaten. When the maize began to sprout a boy and girl of noble blood were drowned; when it began to blossom, four children were starved to death in a cavern." Another custom was that of starting the new fire each temple year upon the naked breast of a slave.

Such a division would give Savagism, including the Negroid Race; Barbarism, comprising the Americ Race; Arrested Civilization, the Mongoloid and Archaean White; and Progressive Civilization, the Caucasian.

The fourth division of mankind, that of 'Progressive Civilization,' truly seems to be the heritage of the Caucasian race, the home of the various branches of which, having absorbed aboriginal inhabitants, extends from Ceylon to Scandinavia, and in whose grasp North America and Australia have fallen. It would be taken to include the Greeks, Romans and the European nations generally. Whether the effect of Caucasian influence upon the arrested development of the Mongoloid (as in Japan) will evoke a new growth in that division of the race is not improbable, and if so, would only serve to show that Mongoloid civilization culture is true progressive civilization, temporarily arrested but only slumbering.

American civilization is not less deserving of study than those of earlier times and lower rank. Its startling rise and its supremacy in the one aspect of industrial adaptability are characters of the most profound interest. The causes that have operated within three centuries to bring together the nuclei in Virginia, in Maryland, in New Amsterdam and in New England, to add to these elements the

most diverse possible, and therefrom to educe a civilization with a national ideal different from any of those that have gone before, is a matter for very careful study.

It would almost seem as though the culture of the United States was not so much slightly changing the old channels, as cutting new ones. The occultism and mystery of the east is hetero-mundane to the purely scientific attitude of the ideal European mind; but the endeavor on the part of the American to transliterate pure into allied Science and intellectualism into utilitarianism is again more different still. It is not difference of degree, but a difference of kind, and those who are heedfully observing the culture-development of America are beginning to see that the New World will, when she reaches a full strength, give to Man a Culture different from any that has gone before.

That this is not yet realized perhaps is due to the fact that the prophets of that spirit have not yet appeared; that the poets, artists, architects, sculptors, dramatists and scholars, are still in the lotos-dream of European ascendancy. The engineer, the mechanic, the inventor, the industrial monarch, the railroad king, and the Great Khan of trade, are more in keeping with the growing American spirit, and hence arises the anomaly of those men's names being upon people's lips who seem to have naught else but wealth to recommend them as the cause of fame.

It will appear in course of time, however, that the public sense is none so trifling a thing, and that these men stand for an ideal yet barely grasped at, hardly felt, wherein utilitarianism will arise into a mighty force, and the spirit that shall move men's souls will be that of prizing usefulness to their fellowmen more than their favor. To desire to grow rich for the sake of selfish luxury is an ignoble seeking, and it seems unjust to American culture to suppose that this is the cause of the money-making spirit; it would seem juster and not a whit less true to believe that the strife for the acquisition of wealth is due to an

inherent sense that the masters of the world in the future will be Americans and that the resources of the world should be under their hands.

The old Chaldean culture lent a magic spell over the mind of Man, yet made him conscious of his Destiny; the Grecian culture founded itself upon estheticism, but taught him Beauty; the Roman culture was built up by the sword, yet Justice and Law became its heritage; Latin Christianity called in the aid of superstition, yet from it Man learned Reverence; northern Christianity was constantly riven asunder in theological bickerings, yet did the race learn Religious Liberty; France passed through the scenes of the Terror, to teach the Kinship of Classes; England was forced to never-ceasing vigilance in the waters around her island home, that Dignity and the power of National Protection might be made known; and America, amid her throes and struggles, stands as the Good Samaritan to the world's wretched ones, tending them, guarding them, teaching them to be worthy of the land of their adoption. America is yet a child, but men are beginning to see that her ideals are not borrowed and that ~~her~~ Culture is her own.

MEDICINE

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MEDICINE

CHAPTER I

THE ANCIENTS

THE development of anatomy and physiology, since the earliest days of mankind, is so closely interwoven with the history of medicine and philosophy that no consideration of the medical arts is possible without some realization of the strange complications of thought at that early time. It is Science now, but it was Mystery then. Mystery overhung the thinkers of antiquity, and nowhere did this element of magic and of wonder have a stronger hold than in the strange humors of disease, for which they could find none other explanation than that they were punishments inflicted by gods or demons.

With this well-nigh universal conception of the causes of disease, it followed naturally that healing could only attend the propitiation of the gods by suitable sacrifices, prayers and penances, and the offices of priest and physician were unified. But instead of this aggrandizing the doctor's importance, public opinion veered. Inasmuch as so great stress was laid upon the gods to maim or to heal; so much the less power had the physician-priest, for was he not a mere tool of the gods? It was not he that healed. Even to within a century or two ago a "barber-surgeon," as he was called, was held in the greatest contempt, and the development which has led to the medical profession

holding a place of eminence in the minds of men is one of the most startling evolutions of modern times.

This sudden elevation reveals a public consciousness of the worth of true knowledge. Whereas the physician of the ancients was also priest, philosopher and scribe, and could not specialize or attain distinctive knowledge in any one branch of the healing art, for the reason that those branches were incompletely developed and not much was known of them, now the physician is acutely trained to a definite portion of his profession and speaks thereon with authority. Moreover, he must not only know his subject and know it well, but he must be a man of culture, of wide general knowledge and keen understanding of the men and times in which he lives, and he must also be a chemist, a biologist and a physicist; indeed there is not a branch of science which he does not subordinate to his effort to alleviate pain and raise the life-standard of the human race.

The peerless knowledge of the ancients in the Mathematical Sciences and in the Fine Arts naturally raises the question why anatomy, physiology and organic chemistry were not independently studied nor worked out with any analytical skill. The structure and functions of the human body were little known and less understood. That the confusion of mind incident upon the commixture of the Art of Medicine with Philosophy and Religion went far to cause this neglect is true, but it seems that an even greater barrier lay in the absence of freedom of study and of expression.

All the religions of the past taught that to lay critical hands upon a body was wrong and even impious, and this idea was so firmly rooted that for centuries such a prohibition is found in civil law. In many cases the dead body was held as more sacred than the living, esteemed peculiarly worthy of reverence and even worship, and even yet the old idea has not entirely died out which considered anatomical research and dissection to be a sacri-

lege. Knowledge was perilously gained, and with the study of anatomy and physiology thus under ban it is small wonder that the physicians were able to do little to stay the scourges of the appalling epidemics which literally mowed down hundreds of thousands in the Middle Ages. Few developments of human thought show a truer following of a high ideal than the advance made through centuries of toil to stay the pain and alleviate the distress which accrue from "the ills that flesh is heir to."

In proportion to the progress of civilization and refinement, more definite and well-reasoned attempts have been made to remove or alleviate disease and to repair any of the gross injuries to which the human body is constantly exposed. Subject as it is to the influence of various noxious agents and to a consequent derangement of its functions, to many painful affections and to the loss of its powers and actions, men have always been anxious to remove or relieve these conditions. Thus, in the earliest periods of society, mankind must have been aware of the relief which was given in the derangements of alimentation by evacuation and would probably have discovered, incidentally perhaps, that certain vegetable agents promoted this operation. In external injuries they would find that rest, pressure, heat or cold gave relief, as, for example, when pressure stopped an excessive flow of blood. This rude species of medical and surgical practice has been found to exist in newly discovered countries, even when in the most barbarous state, while it has been observed that the improvement in the healing art has been nearly proportionate to the advancement of the other sciences of life and to the gradual progress of knowledge on all subjects connected therewith.

The Egyptians had several divinities who presided over the cure of disease. The principal of these deities, Isis, was at once the sister and the wife of Osiris. She had demonstrated her eminent medical skill by recalling to life

hier son Horus. Imhotep, the Egyptian Æsculapius, who was one of the Memphis gods, and Chunsu, the counsellor of the sick, were of lower rank. The cat-headed Pacht (Bubastis) and Apis were worshiped as the deities of parturient women or of child-blessedness, for children among the Egyptians were esteemed a great blessing.

The medical knowledge of the ancient Egyptians was tolerably extensive, and, gauged by the measure of those early ages, by no means unimportant. It was at all events quite characteristic. Medicine was divided into the science of higher degree (conjurations, dissolving the charms of the gods by prayer, interpretations of the revelations received by the sick during incubation in the temples) and ordinary medical practice. The former was pursued only by priests, who aimed to get further control over their people by pretending to have command of Nature.

The pathological knowledge of the ancient Egyptians comprised a knowledge of fever and of diseases of the eyes, in the treatment of which their physicians enjoyed special reputation throughout all antiquity. They must therefore be regarded as the earliest oculists. They were even summoned to foreign courts and furnish the earliest examples of practitioners who traveled among foreign people.

In physiology they held that until the age of fifty years the heart gains annually about two drachms in weight, but that afterward it loses about the same amount each year, so that finally, in old people, death is occasioned by this continual loss. Also they assumed that four demons ruled over the body. As Buchta points out, hunger and thirst were not regarded as bodily wants, but as quasi-poisonous substances which forced themselves into the body and required to be neutralized by eating and drinking, in order that they might not destroy it. A similar superstition also prevailed regarding the dead, and thus these too required food.

The Egyptians, who did not shrink from human dissection as much as the Greeks, were indeed acquainted with

anatomy, but not to the degree which might be expected from their other medical skill. Yet Athotis, the son of King Menes, who is himself said to have been a physician, had written on anatomy. Both of these were kings and thus furnish evidence of the high estimation of medicine and of physicians in Egypt. The Egyptians assumed theoretically the existence of two kinds of vessels and nerves or tendons, of which there were in the body from twenty-four to thirty-two. Such a nerve extends from the little finger to the heart; hence the custom of dipping this finger in their libations. They were acquainted with the heart, the lymphatic glands and the crystalline lens of the eye.

When the method of embalming is considered, it is manifest that the custom could result in no anatomical knowledge, even if the persons who made embalming their business had been of a different class from that to which, as a matter of fact, they really belonged. The mode of procedure in embalming is clearly known. In the first place it was determined by the friends of the deceased in which of the three prevalent styles the operation should be performed. In the more expensive styles patterns were exhibited for their selection. If the most costly form was selected, one of the sacred scribes marked eight lines, one upon the left side. Following the direction and length of these, an associate from the disreputable and most deeply despised caste of the Egyptians, the "paraschites," with a sharp stone—an evidence of the high antiquity of the custom—made an incision into the cavity of the abdomen. He then ran away, so as not to be stoned for his offence against the dead.

Now began the work of the embalmers, who existed as a guild even to the time of the Roman Empire. The viscera were removed and preserved in canopen, *i.e.*, vases of clay, limestone or alabaster, the lids of which were decorated with representations of one of the four genii of the dead—Amset, Hapi, Tuamutef and Khebsennuf—to whom

the canope in question was dedicated. After the cranial cavity was cleared of the brain by means of hooks inserted through the nose, the cavities of both the cranium and abdomen were filled with spices, myrrh and cassia. The salters then laid the corpse in a solution of carbonate of soda (natron), where it was left for seventy days. At the expiration of this period it was again washed in caustic soda, then coated over with gum and finally wrapped in a



Fig. 1—EGYPTIANS BANDAGING A MUMMY

cloth of fine linen. In good mummies the hair and nails are preserved, but the eyeballs have obsidian eyes inserted in them.

The corpse, thus prepared, was placed by the friends in a bivalvular wooden coffin, hollowed out to suit the size and form of the body and often adorned with beautiful hieroglyphics. The mummy, thus completed, was then placed in the catacombs, where, as is well known, they have been found in a good state of preservation after thousands of years.

In embalming "of the second class" melted cedar resin was injected into the unemptied cavities of the body, which was then salted down for seventy days, after which the viscera and resin were removed together. "Embalming of the third class" consisted in simply salting the body after it had been washed. Besides these methods, the Egyptians also often buried their dead in the ordinary way. In fact, the poor were even buried in the sand without any shroud and those possessed of a little means in arched vaults built of brick.

The Egyptians were acquainted with a considerable number of drugs and had numerous formulæ for their preparation. Prominent remedies were opium, strychnus, squill and vegetable remedies in general, though medicines of animal origin and of a kind disgusting to modern ideas also were employed. The Egyptians made use of metallic preparations such as antimony (a paint for the eyes), verdigris and white-lead. Ointments, oils (which, in consequence of their excellence, were imported from Egypt by even the Greeks in Hippocrates' time), plasters, pills (mixed with honey and afterward rolled into form) steam for inhalations, poultices, enemata, decoctions and such like were recognized preparations.

Mental diseases were blamed upon the demons, and amulets were in common use, especially in the treatment of diseases of the nervous system. Astrology was called into counsel in the treatment of disease, and by reason of the theurgic character of ancient Egyptian character it was susceptible of change with every variation of worship. In the Middle Ages, it is remembered, Egyptian wisdom was regarded as identical with sorcery, the search for the philosopher's stone, alchemy and astrology; while even to-day the gipsy is not a little feared by the ignorant classes.

The astrology of the Egyptian was not comparable with that which developed in the valley of the Euphrates. In the gray dawn of antiquity there immigrated into Baby-

lonia from the north a Turanian people, the Chaldees, whose dominant element consisted of the servants of the deity. The latter thus rose to be an influential priesthood, and accordingly the name Chaldee—the Magi of the Bible—was employed to designate both these immigrants and their priests. The Chaldees enjoyed great esteem as mathematicians, astronomers, astrologers, interpreters of dreams and (theurgic) physicians. Aside from the Chaldean Magi, however, Herodotus avers that the Babylonians had no regular physicians who visited the sick, but the latter were exposed upon the streets and interrogated by those who passed. If any of these visitors had recovered from a similar disease he was expected to counsel the invalid as to the means by which he had been cured.

The Old-Persian medicine too, so far as can be judged from the exceedingly scanty information now possessed, was theurgic in its character. Leprosy was ascribed to offences against the sun, and the sufferer was compelled to live apart from the healthy. Amulets played an important role, for each city and every province had its genius. Sparkling stones were worn for love of the genii, and in this way originated the reliance upon and belief in the virtues of stones. They served to avert evil and were especially useful against the venom of serpents and scorpions; they mitigated the pains of disease and of wounds, since it was believed that fire and water, the male and female Genius of Nature, were active in them. Hence the doctrine of the Magi as to their composition, hence the prescriptions as to their use. The Persians possessed an extensive knowledge of poisons. The Houma-drink—a drink prepared from the plant Houma and which possessed almost divine powers—was prescribed by the physicians for pains in the limbs, catarrhal obstructions and urinary diseases.

In reviewing the medical culture of the Phoenicians it is important to remember that in the papyrus Ebers it is stated that one of its books is the work of a physician of

Byblos. What is known of this book permits the conjecture that much more important medical knowledge than has been heretofore suspected was possessed by this Semitic race. Not only was it distinguished for its technical, nautical and meteorological knowledge, as well as for its activity in colonization, its commerce and its luxury, but it also exercised an important influence upon the Greeks, which appears in Greek medicine. That the Phoenicians indulged in an extremely sensual religious worship is known. It is also known that their supreme deity, Baal-Zebub (the god of flies), the Beelzebub of the Bible, was a god of medicine and was interrogated as an oracle of health and disease. His priests were clad in red clothing, possibly the earliest example of the red garments of the physician. The Carthaginians, as Phoenician colonists, differed but slightly in their medical customs from that of the parent stock.

Early Jewish medicine is especially conspicuous for its absence. In consequence of the stern prohibition against contact with the dead, true anatomy was not thought of, the bones and vessels being only very vaguely mentioned, while nothing is known of any Jewish physiology. The almost complete absence of a pharmacology among the Jews is remarkable, for they were acquainted with a great number of plants, and the Egyptians, among whom they had lived, had a large number of remedies which they might have appropriated. Figs, and the heart, liver and gall of fishes are mentioned as medicines, and bathing in the Jordan is deemed a remedy for leprosy. This lack of remedies is doubtless to be explained by the purely theurgic character of Hebrew medicine. Yet the mortality of the Jews was not, for this reason, any greater than that of other people who employed "remedies" in abundance.

The Hebrews, like all other peoples, regarded the prevalence of diseases, and especially of important epidemics, as punishment inflicted by a deity on account of their sins.

For relief, therefore, they resorted to repentant prayers and the mediations of their priests. They did not see any need for physicians. But the great lawyer, Moses, while he omitted any surgical or medical practice, gave his people the first elementary code of public hygiene. It contained the specific directions in regard to the kind and preparation of food; the slaughtering of animals; the burial of the dead; the regulation of marriage and sexual relations; the diagnosis and isolation of cases of leprosy and some other contagious diseases. The only surgical procedure given was that of circumcision, which was performed by the priests.

The later knowledge of the Jews is found in the Talmud, the medical contents of which are fairly complete for that period. Its Surgery embraces a knowledge of dislocations of the femur, contusions of the skull, perforation of the lungs, œsophagus, stomach, small intestine and gall-bladder, of wounds of the spinal cord, trachea, pia mater, of fractures of the ribs (all of which were considered very dangerous unless immediate medical aid could be obtained), of oral and nasal polypi, the latter of which were considered a punishment for past sins. In sciatica a curious direction is given to rub the hip sixty times with meat-broth. Besides the ordinary operations, *e.g.* venesection, which was performed by mechanics or barbers, mention is made of circumcision and of the operation for imperforate anus. The execution of the latter operation is described very minutely.

The Talmudic pathology ascribes diseases to a constitutional vice, to evil influences affecting the body from without or to the effect of magic. It recognizes, among other things, the origin of jaundice from retention of bile and of dropsy from suppression of urine. The latter in general was divided into anasarca, ascites and tympanites. Prognostically it is declared that hydrocephalus internus, or water on the brain, is always fatal, while hydrocephalus externus is not necessarily so; that rupture and atrophy of

the kidneys are followed by death; that hydatids, or cysts of the liver, on the contrary, are not fatal; that suppuration of the spinal cord, induration of the lungs, etc., are incurable—views which may have been based upon the dissection of animals and may be considered germs of pathological anatomy. Sweating, sneezing and dreams promising a favorable termination of existing disease pass for critical symptoms.

In therapeutics natural remedies, both external and internal, were employed, as well as the arts of magic. The rabbis, at other times so strict, allow to the sick even prohibited articles of diet if they have a desire for them. Among their special prescriptions may be noticed onions for worms; wine and pepper in disorders of the stomach; goat's milk in dyspnoea (labored breathing); emetics in nausea; a dog's liver for the bite of a mad dog; injections of oil of turpentine in cases of stone in the bladder; a drop of cold water in the eye in the morning, with warm foot and hand baths in the evening, for sore eyes; bleeding and the warm baths of Tiberias. Asafetida and many other drugs are certainly derived from Grecian medicine, the laying on of hands, prayer and conjurations with less certainty to the same source. In Dietetics it was recommended before the age of forty to take more food than drink, after that age to reverse the habit; after meals to eat salt and then to drink water freely, but not to work too much nor to walk, sleep nor indulge in wine. On the other hand, it is advised to form regular habits, to bathe, anoint and wash frequently.

The Anatomy of the Talmudists is based chiefly upon the dissection of animals, though Rabbi Ishmael, at the close of the first century, dissected, or rather "skeletonized," by boiling the body (dissection in the interests of science was permitted by the Talmud), on which occasion he found 252 (instead of 232) bones. They recognized the origin of the spinal cord at the foramen magnum and its termination in the cauda equina; allowed two coats to the œsophagus;

included the lungs in two coverings and gave a special coat to the fat about the kidneys.

In Physiology they assume cold, heat, dryness and moistures as component forces. In experimental physiology they point out that removal of the spleen is not fatal and distinguish between salt solution and albumen by the fact that the former, under the influence of heat, deliquesces, while the latter coagulates.

Hindu medicine is one of the oldest in the world. Like the foregoing, it is also a priestly medicine. In its whole extent it grew up upon Indian soil, although at a late period foreign views, especially those of the Greeks, probably were interwoven. The study and practice of the Indian physicians, however, are controlled by regulations, which give evidence of a very earnest and worthy conception of the medical profession and embody truths acknowledged even to-day.

Certain external requirements were imposed upon the physician, the estimation of which is characteristic of the childlike mind of the people, though the adoption of some of them would seem, if not necessary, at least useful for us of the present day. There were demanded of the physician a fine person, absence of passion, decorum, chastity, temperance, amiability, veracity, consideration for the sick, generosity, diligence, earnestness, freedom from boasting, secrecy, a desire for knowledge which scorns not even the lessons of an enemy, and, above all, reflection and independence of thought.

Moreover, it is said:

"A physician who desires success in his practice, his own profit, a good name and finally a place in Heaven must pray daily for the welfare of all living creatures, first of the Brahmans and of the (sacred) cow. . . . The physician should wear his hair short, keep his nails clean and cut close and wear a sweet-smelling dress. Let his speech be soft, clear,

pleasant. Transactions in the house should not be bruited abroad."

The last advice is found also in the Hippocratic oath.

Medical instruction, which comprises the learning by heart of the medical doctrines taught orally, is imparted by the Brahmins and begins in early youth, a regulation which is found also among the Greeks. The pupil must first select a good text-book and then a good teacher. Instruction embraces the theory of medicine and a practical course at the bedside, with the performance of some operations. The pupil must begin to study early in the morning (after having rinsed his mouth and prayed to the cow and the gods) and cease late in the evening. Conference with fellow students is enumerated among the means adapted to give the student a better insight into his studies.

The general Pathology of the Hindus, says J. H. Baas in his excellent 'History of Medicine,' points out as the characteristics of health a serene spirit, clear sense and perfect understanding, uniform warmth from a uniform mixture of the fluids and elements and undisturbed regularity of the secretions and functions of the body. Diseases are divided into natural and supernatural (the work of demons), with subordinate classes, as accidental, corporeal, mental, original and complicating, secondary, internal and external. Pain is considered a symptom of all diseases and fever a symptom of all severe affections. Etiologically diseases are ascribed to an unequal or perverted action of the five common elements—ether, air, fire, water and earth. These, however, in the first place, through the influence of food, season, conditions of the atmosphere and the climate, form proximate causes of disease, while corruption of the three "elementary fluids," bile, mucus and air, is looked upon as the remote cause.

Other evils arise from draughts of air, water, the passions, bad habits of life, insufficient clothing and unclean dwellings. Worms also play an important part in the etiology of diseased conditions of the body or its parts and

the existing superstition to this effect probably had its origin in this Indian idea.

Operative surgery attained such a position among the Hindus that they did not shrink from the greatest and most difficult operations. First may be noticed the dressing of wounds, concerning which the Ramayana says:

"The wounded in battle should be quickly picked up, carried into a tent, the bleeding stayed and upon the wounds should be dropped an anodyne oil with the juice of healing herbs."

Next may be quoted the apothegm:

"The fire cures diseases which cannot be cured by physic, the knife and drugs."

Their special pathology includes among internal diseases rheumatism, gout, hæmorrhoids, inflammations, fever, catarrh, diabetes mellitus (first mentioned among the Greeks by Demetrius of Apamea), diarrhœa, jaundice, cough, verminous diseases, epilepsy, mania a potu, the exanthemata, dysentery and phthisis.

Diagnosis was effected by the aid of the senses and by examination of the sick, and the physician was expected to pay special attention to the pulse, the bodily temperature, the color of the skin, the urine and feces, the eyes, the strength of the voice and the noise of the respiration.

Therapeutics were guided by the curability or incurability of the disease. If the disease belonged to the incurable class the physicians did not take the patient under treatment at all, but advised him plainly, honestly and unselfishly. It is said:

"To go forth upon a narrow footpath to the invincible northeastern tongue of land, to live on water and air until this earthly tabernacle sinks down and his soul is united with God."

Herodotus similarly relates:

"Whosoever among the Indians becomes sick goes out into a desert and lays himself down there. No one

troubles himself about him, whether he be sick or dead."

If, however, the disease is curable attention must be paid in the cure to the disease itself, the season, the organic fire, the age, bodily habit, the strength, the intelligence (according to the Indian ideas the stupid are cured more quickly than the intelligent, because, thinks the open-hearted Susruta, they are more obedient), nature, idiosyncrasies, remedies and the regions of the earth.

The *Materia Medica* of the Hindus is most copious, in fact almost as rich as that of to-day. It embraces remedies from the animal, vegetable and mineral kingdoms, together with the arts of magic. Remedies are used both externally and internally; they are divided into pharmacodynamic classes and are either simple or (as is more frequently the case) exceedingly complex in their nature. Venesection and cupping, especially the former, play an important part. Even inhalations into the mouth and nose by the aid of tubes are known.

In India the ancients had hospitals. Inoculation of the natural and artificial virus of small-pox was practised with a prophylactic view. The Brahmans always performed this operation in the beginning of the warm season. The skin was rubbed, a few incisions made and virus of the preceding year, with which pledgets of cloth had been saturated, was bound upon the abraded surface. The persons thus inoculated were compelled to remain in the open air (Indian method of inoculation). Boys were inoculated upon the outside of the forearm, girls upon the upper arm. Vaccination is now obligatory in the larger cities, but elsewhere the old plan is generally carried out.

Dietetics are carried to the extreme and carefully regulated. The Hindus are forbidden to eat meat.

Their knowledge of Toxicology is considerable. Such an acquaintance with natural history as is necessary to a knowledge of remedial agents is possessed in a remarkable degree. On the other hand, Anatomy forms the weakest

side of Indian medicine. This, however, ought not to occasion much surprise when the prohibition of contact with the dead is considered an offence always to be expiated, though only lightly. The method of preparing bodies and the sole instruments employed in this process are very original, but certainly not adapted to afford a good insight into the structure of the human body.

"Let the physician leave a corpse fastened," it is ordered, "together with its receptacle, in a brook, to macerate in a clear place—a corpse which has a body uninjured, uncorrupted by poison, unshaken by chronic disease, unhandled a hundred times, unclothed—and draw it out when maceration is completed. The corpse at the expiration of seven days should then be rubbed with pieces of bark; he can then with his eyes see the skin and all the external and internal parts."

Hindu medicine must be assigned, at all events, a superiority over the Egyptian and the Talmudic; indeed, it may claim even the very first rank among those examples of medical culture which have not experienced a continuous development. That it was not far behind Greek medicine, both in the extent of its doctrines and in its internal elaboration, furnishes only a very superficial comparison. It cannot fail to command admiration when the very early period in which it developed and attained so high a grade is considered.

The Chinese are little further advanced now than they were ages ago, except in the large cities, where foreign influences cannot help but be felt. The ancient and unlimited liberty of choosing one's occupation in China has resulted in making the medical profession enormous in point of numbers. From the earliest times, therefore, there have been found several physicians in every village. In China any person may be a physician to the poor without having given any previous evidence of his professional

competency. Any one, moreover, may assume the title of physician. The court physicians only, as a matter of precaution, are compelled to pass an examination before a college at Peking.

Chinese apothecaries, before they can carry on their business, must have passed an examination and must exhibit a diploma from the examining board. Powerful remedies, like opium, arsenic, etc., are forbidden to be dispensed by them without the prescription of a physician. The pharmacies are fully supplied with the necessary drugs (a Chinese pharmacopœia contains 650 different kinds of leaves) and they are kept in a very orderly condition. Besides pills as large as musket-balls, their proprietors also prepare love potions. The prescriptions of physicians are prepared by the apothecary, but the latter combines also with his business the occupation of fortune-telling.

Chinese surgery embraces the practice of acupuncture, which is regarded as a universal remedy and has for its object the quickening of the "vital spirits." It is practised by twisting or driving in a needle inserted into the body. By this operation a free passage is supposed to be made for the "winds." Besides this, Chinese surgery includes the application of moxas, cupping, inoculation (which the physician Go-mei-schan is said to have invented about A. D. 1000) and paracentesis of the eye and bleeding. The latter operation is, however, practised rarely and is performed with a small lancet, after which tallow and oil are applied to the wound without any bandage. Enemata are not employed, since they are offensive to the modesty of the dignified Chinese. Under ordinary circumstances they make shift with poultices. In this line cats' liver and fowls' entrails are specially popular, while fractures are treated by extension.

Kneading of the muscles (massage), which is also said to have been in use 2,000 years before the present era (though, according to Wernich, of Japanese origin), is likewise practised. The Chinese also claim to have been

able for thousands of years to produce anæsthesia by means of the preparation Mago. Inoculation of modified small-pox, too, has been practised by them. Their surgeons are extremely ignorant, are assigned to inferior service and receive little pay.

The pathology of the Chinese is very incomplete. All diseases, especially epidemic diseases, are ascribed to spirits and winds, cold and warm humors, etc., and are assigned, in accordance with their benign or malign character, to Yo (the good principle) or Yn (the evil principle). To Yo belongs acute inflammatory fever, to Yn hectic fever, etc. There are, according to Chinese pathology, 10,000 varieties of fevers. Among their diagnostic procedures are examination of the tongue and the eyes and feeling of the pulse. The pulse flows from the "spirits" of a certain part of the body, which manifest their presence in a given place. By means of it both the cause and the seat of disease are to be found.

The art of feeling the pulse is very old and extremely elaborate. It is performed elegantly by placing several fingers upon a certain point and then raising or depressing each in turn, as is done in playing the piano—the Chinese "play upon" the pulse instead of feeling it. In this practice the changes of the moon and the season of the year are considered, according to certain rules. The performance often lasts several hours. In diseases of the heart the left pulse is investigated, in those of the liver the right, etc. Each speck upon the tongue and every discoloration of this organ points to special diseases and viscera.

Chinese pharmacology contains remedies from the vegetable and animal kingdom almost exclusively and is very copious. It includes elephant's bile, dried spiders, bugs, toads, lizards, snakes, claws, ears, tongues, hearts and livers of numerous animals, excrements, dragon-bone, cotton, ivory, musk, rhubarb, gentian, camphor, Chinese seeds, leaves in large doses and innumerable other things. The genuine ginseng-root (worth about \$25 an ounce)

and the edible nests of the swallow are considered veritable panaceas and are specially prized by the Chinese.

In therapeutics great importance is laid upon strict diet, frequent baths, etc. The chief task of the physician, after making his diagnosis, is to remove the *materia morbi*, which has entered by way of digestion, the nerves or the circulation. In general the maxim '*contraria contrariis*' is followed, hence in debility, *e. g.*, the extract of tiger's blood is prescribed. Almost every animal supplies a distinct specific, particularly its blood and its liver. Often too, especially among the wealthy, the whole store of Chinese remedies must be exhibited until the proper specific is found. If the patient dies, according to the Chinese idea, he is indeed cured by the suitable remedy, but the physician has not had the time to rid him of his poisonous drug, and, as the result of this unfortunate want of time, the patient is doomed.

Anatomy and physiology occupy the lowest grade in Chinese medical science, though a few very old and imperfect plates are in existence. In their veneration of the dead, dissection of the human body is of course excluded. The Chinese assume six chief organs in which the "moisture" is located, *viz.*, the heart, liver, two kidneys, spleen and lungs; six others in which is the seat of "warmth," *viz.*, the small and large intestine, the gall-bladder, the stomach and the urinary apparatus. They enumerate three hundred and sixty-five bones. The Chinese, in place of the fire and earth of the Greeks, class wood and metal as elements and heat and moisture (whose union produces life, their separation death) are regarded as fundamental qualities. The circulation flows outward from the lungs five times in twenty-four hours and terminates in the liver. The bile, as it is one of the most powerful remedies so also is it the special seat of courage; the lungs give origin to the voice; the spleen is the seat of reason and, with the heart, furnishes ideas; the liver

is the granary of the soul, while the stomach is the resting-place of the mind.

In the pathology of the ancient Japanese medicine external and internal diseases are said to be distinguished. A disease peculiar to the Japanese pathology is the lesion of the spine, called Kakkeh. The most wonderful things are regarded as therapeutic measures—*e. g.*, in small-pox the decoration of the sick-room with red hangings. On the whole, the medicine of the Japanese bore almost as strong a theurgic character as that of the Chinese, from whom, as has already been seen, it was adopted. Both too, may be considered philosophical sciences, inasmuch as neither was ever a sacerdotal medicine proper.

Equally ancient, the Celts and the Teutons possessed a medical mythology displayed among the demi-gods. Thus there is a female Æsculapius, Eira; another goddess, Fricco, invoked for fruitfulness in wedlock, and Holla, the aider of women in labor. On the other hand, Hela, a ghastly form, received all those who died of disease into her residence, Niflheim, which contained the hall, Elidnir (pain); her bed, Koer (disease), and the table, Hungur. Some fragments of genuine medical practice and information of a later period have been preserved. Thus the Scandinavian physicians in cases of dropsy are said to have had recourse to the actual cautery and in asthma to have resorted to venesection, while for bearing the wounded those warriors were selected who possessed soft hands. Their anatomy mentions two hundred and fourteen bones, three hundred and fifteen vessels and only thirty teeth. Their physiology locates love in the liver, passion in the bile, memory in the brain—data which remind of Indian ideas.

CHAPTER II

THE GREEKS

THE earliest traces of European medical history are to be found in the Homeric writings, which, although they are Ionic in origin, at the time when they first clearly appear had become indigenous to the soil of Greece. Prominent in the Hellenic pantheon was Æsculapius, one of the sons of Apollo, who was reputed to have the power of restoring the dead to life, but who had been slain by Jupiter at the request of Pluto because he had restored to life an enemy of the god of the underworld. He was the pupil of old Chiron, the centaur, possessed of marvellous powers of healing and of song, and is usually represented seated holding a bundle of medicinal herbs.

He was deified in the Greek life, but only in the anthropomorphic sense of the lesser gods, and while temples were erected in his honor, they were merely the nuclei around which were gathered places for the housing and treatment of the disabled and diseased. Those who cared for the sick in these places were called Æsclepiadæ, being both priest and physician. Their duties were mainly the treatment of surgical cases, except that dietetics and climatic therapeutics were well understood. These temples were generally located in healthy situations, the patients enjoyed rest and leisure and diversions were plentiful for the mind. In fact, they were not unlike the modern Spa and health resort.

There seems to have been no writing or recording for future reference. The first physician known to put his

thoughts and observations down on paper was Hippocrates. So that it may safely be asserted that the culmination of Grecian mythological medicine is in the great genius



Fig. 2—CHIRON THE CENTAUR AND ÆSCULAPIUS.

of Hippocrates, who really elevated medicine to its proper rank of a science. It is generally admitted that although Greece cultivated the arts and sciences with so much success, yet, in the first place, she borrowed them from the neighboring nations, principally from Egypt and Phœni-

cia. For a long time those in Greece who wished to acquire a larger share of knowledge, either theoretical or practical, than was possessed by their own countrymen, visited Egypt as the great storehouse of science and learning.

The practice of medicine remained for a considerable time hereditary in the family of Æsculapius and in a great measure confined to it. As the field of healers increased, practitioners were all classed under the general name of Æsclepiadæ, although this may have been narrowed to those who were both priest and physician. The process of treatment was mainly magic and incantations and not based on an exact knowledge of human anatomy or its functions.

In those days of almost constant warfare there must have been wounds of all varieties. More men were hurt or disabled temporarily than killed outright, so that practical surgery was further developed than any other phase of the medical art, and the treatment of wounds achieved wonderful results. It was efficacious in its simplicity; foreign bodies were removed, the wounded parts were placed in as normal a position as possible and certain healing vegetables, either balsamic or styptic, applied. Wine and other stimulants were used to support the patient in his shock and bandages and splints were applied even as they are nowadays.

Over a long period of several centuries, of which there is scant record and only a hint now and then, there was very little advance in the progress of medicine. The Æsclepiadæ were the sole practitioners—the guardians or superintendents of the many temples devoted to Æsculapius. Of these there were several which became quite famous as schools—those of Cos, Cnidos and Rhodes. The priests connected with these institutions became divided, thus early laying the foundation for the two great sects of Dogmatists and Empirics, which long divided the medical school. The school of Cos assumed more of a philosophi-

cal cast, attempting to unite reason with experience, while the school of Cnidos sought mainly to observe and collect mere matters of fact.

The school of Cnidos is said to have laid especial weight upon the subjective statements of the sick, the relation of the symptoms to individual parts of the body and the use of active remedies, especially drastics. Less attention was devoted to diet. It cultivated the science of diagnostics and recognised some auscultatory signs—*e.g.*, the pleuritic friction sound, and it satisfactorily distinguished many diseases, such as phthisis, typhus, diseases of the urinary bladder, the kidneys, the bile, etc. The Cnidians also performed even major operations, like trepanning the ribs and excision of the kidneys, and, though always empirics, they were bold operators. In opposition to the physicians of Cos, however, they discarded venesection.

The school of Cos (which was flourishing as early as 600 B. C.), in contrast to that of Cnidos, cultivated especially objective investigations, symptomatology, prognosis, the relation of the symptoms to the entire body, etiology and expectant and mild therapeutics, though it recommended venesection; in short, it practised all that is worthy of praise in the medicine of Hippocrates and the Hippocratists. These two schools are the first examples of those two opposing tendencies which have characterized medicine down to the present day.

The name of Pythagoras, who founded the so-called Italian school, stands preëminent, but even his history is enveloped in much obscurity. He devoted most of his life to the study of natural knowledge and advanced the various departments of science, especially in the knowledge of the structure and actions of the human frame. He is said to have dissected the bodies of animals and to have known something of anatomy. He taught large bodies of students at Crotona and was a man with a mind far above his time. He travelled extensively throughout Egypt, where he

learned mathematics and other branches of Egyptian knowledge. He believed that the soul of man emanated from a God and was immortal, that the basis of life was heat.

But while Pythagoras applied salves and poultices to wounds, he did not approve of or practice surgery. Diet and gymnastics, he declared, must maintain health. Disease was due to the demons, hence prayers, offerings and music were used to restore harmony. His followers believed that magic resided in certain plants, especially the cabbage, which was a special food of the sect.

Gymnastic medicine was a phase in the science on which the Greeks laid special stress. There were schools founded for the practice of gymnastic exercises under charge of trainers who supervised the health of their pupils, treated injuries and also internal diseases. They were often capable physicians, but had no standing as such.

Among the pupils of Pythagoras, Alcmaeon of Crotona was the most famous in medicine. He was manifestly the first (animal) anatomist and is said to have discovered the optic nerves and the Eustachian tubes. Health, he affirmed, depends upon the harmony, disease upon the discord of the component parts of the body; of heat and cold, dryness and moisture, bitterness and sweetness, a similar antithesis, a doctrine amplified in later systems of medicine. His theory of hearing is well worth notice:

"We hear with the ear because it contains a vacuum and this occasions the sound. In the cavity, however, the sound is generated, the air resounding against it."

The atomic school presented a widely different purview. This school sought in matter the foundation of the world and of thought; indeed it professed to find the principle of all things in the infinitely minute identical, altho these atoms were not eternal nor illimitably divisible. Within these were believed to reside order, position, form and motion. They differ in size, and to this difference their weight corresponds. The differences of the elements, fire,

water, air and earth, depend upon differences in the form and size of the atoms.

The soul, it was said, consists of round and smooth atoms, and its expressions, like life in general, are a result of the motion of the atoms. These smooth and round atoms exist in the whole body. In special parts they are particularly active—*e.g.*, so that the heart occasions wrath, the liver desire, the brain thought. The perceptions of the senses originate in the motion of the atoms of external objects (whose image they are) toward the organs of sense and produce in these organs a palpable impression, the perception. Spirit and body are identical; a healthy condition of the brain implies mental health and disease of the same organ implies mental disease.

To a great extent the way seems to have been prepared for the coming of a leader in science. The power and civilization of Greece had reached its zenith; great military expeditions against Persia had been successful. No other nation had approached her in any field of learning—history, art, philosophy—and she had the world's greatest statesmen. The art of writing had come over from the Phœnicians, so that records of all sorts were kept. Hippocrates, called the Great (460 B. C.), came from a family of physicians and received a thorough education both at home and abroad. He recognized the great fundamental truth—that the basis of all knowledge is the accurate observation of actual phenomena and that the correct generalization of these phenomena should be the sole foundation of human reasoning. He was thus a mixture of the two great schools which were formed after his death and which divided the medical profession for many years into dogmatists and empirics.

Hippocrates was a patient and very accurate observer and an industrious writer, being the first to keep full records of all his studies and observations. He is justly called the "Father of Medicine." Especially was he the creator of profane, as distinguished from sacerdotal medicine

which had prevailed until his day; of public, in place of the preceding secret medicine. In a word, he was the great founder of scientific medicine and of artistic practice.

The general pathological views of the Hippocratists are based upon the assumption of the four elements, water, fire, air and earth, whose mixture and cardinal properties—dryness, warmth, coldness and moisture—form the body and its constituents. To these correspond the cardinal fluids, yellow bile, blood, mucus and black bile, in the order mentioned. (Herein lies the first theory of humoral pathology.) Health consists in a uniform action and reaction, disease in an irregular action and reaction of all these upon and between each other.

Diseases are cured by restoration of the disturbed harmony in being and the action of the elements, elementary qualities, cardinal fluids and cardinal forces. Nature, or the vital force inherent in the body, accomplishes the cure, however, in the best way. If Nature works undisturbed, the disease runs a regular course through the three stages of crudity, coction and crisis. In the first of these a degeneration of the fluids predominates; in the second they are prepared for evacuation; in the third they are removed. If this course fails, and especially if the "crisis" is wanting, there result secondary diseases or incurable conditions. The crises occur particularly upon the odd, so-called critical, days.

Hence the interference of the physician (and in this his art consists) is directed always to choosing the right instant for lending aid. This is especially the case in fevers, which are caused by heating or excess of mucus due to a check of the secretions. Besides the proximate causes of disease mentioned here and above, Hippocrates constructed especially the important doctrine of remote causes. Such are offences against a judicious mode of life, climatic and meteorological influences, the peculiarities of the season, endemic and epidemic constitution, place of residence and similar predisposing causes.

To this was joined dietetics, a science also founded by Hippocrates. This science regarded the age—"old persons use less nutriment than the young"; the season—"in winter abundant nourishment is wholesome, in summer a more frugal diet"; the bodily condition—"lean persons should take little food, but this little should be fat; fat persons, on the other hand, should take much food, but it should be lean," and similar rules. In addition, respect was also paid to the easy digestibility of food—white meat is more easily digested than dark—and to its preparation. Water, barley-water and wine were recommended as drinks. Baths, anointing, gymnastic exercises and the frequent use of emetics were also commended as dietetic measures, and the dietetic principles of Hippocrates in febrile diseases are substantially observed at the present day. By means of such precepts Hippocrates extended the doctrine of indications, which constitutes one of his greatest services to medicine.

The diagnostics of Hippocrates (though he does not recognize any such special branch) was founded especially upon objective investigation by means of the senses and made use of every aid. The ear applied to the chest of a patient suffering with pneumonia supplied a knowledge of the mucous rale ("like the bubbling of boiling vinegar"); the sight furnished a survey of secretion and excretion, the bodily frame, the attitude of the body and its members, the gait, etc.; feeling (the hand upon the chest or abdomen) supplied an idea of the bodily temperature and perhaps likewise of the pulse (though he certainly knew nothing of counting the latter), and the taste and sense of smell equally were put to service.

One of the chief services of Hippocrates to medicine was the foundation of the science of prognosis. This was based upon the excellent maxim:

"In order to be able to prognosticate correctly who will recover and who will die, in whom the disease

will be long, in whom short, one must know all the symptoms and must weigh their relative value."

It considered the perspiration, the sleep, mucous rales in the throat, the visage (*facies Hippocratica*) and the appearance or absence of the "crises" on the appointed days.

In etiology he paid particular attention to age, constitution, meteorological influences, etc., as is seen in the following passage:

"Catarrhs are dangerous in old people when a dry spring follows a winter with south winds and rains. If, however, the summer is dry and north winds prevail, with south winds in a rainy autumn, coughs, hoarseness and catarrhs arise."

The surgical knowledge of Hippocrates was considerable, both as regards the number of diseases recognized by him and their treatment with or without operation. Fractures are handled particularly well as regards the method of reduction and dressing, the mode of repair and the duration of this process. If a fracture is healed with considerable shortening, he is of the opinion that it is better to break the corresponding sound bone, so as to equalize the shortening. The same may be said of dislocations. Hippocrates recognizes dislocations of the humerus inward, downward and outward:

"The head of the humerus is often luxated (dislocated), but not upward, in consequence of the acromion; nor backward, by reason of the scapula; nor forward, in consequence of the biceps muscle; but rarely inward or outward, yet frequently and chiefly downward."

He employs also a great number of methods of reduction. Diseases of the joints (and their treatment by massage) and wounds, especially of the skull, are well managed. The latter, in consequence of the fact that, until the time of the discovery of explosive weapons, arms designed to strike or cut were used, formed the favorite field of surgical labor. Hippocrates also recognized the

fact that wounds of one of the cerebral hemispheres produce paralysis or spasms of the opposite side. The treatment and healing of wounds by first and second intention, fistulæ, ulcers and tumors were also judiciously discussed. Hernia was less fully treated. The hot iron was employed frequently, a practice to which reference is made especially in the famous aphorism:

"What drugs fail to cure, that the iron (or knife) cures; what iron cures not, that the fire cures; but what the fire fails to cure, this must be called incurable."

His surgical therapeutics recognizes a very judicious plan for reposition of the gut in prolapsus ani. Other surgical remedies were bandages, poultices, plasters, ointments, styptics, caustics, cold and compression, suppositories, pessaries, enemata, cupping, etc. The rudiments of orthopædic surgery are also to be found in Hippocrates, who, as Kroner points out, treats club-foot with suitable manipulations, bandages and proper shoes.

The most brilliant and eternal contributions of Hippocrates to medicine are his therapeutic maxims:

"Follow Nature."

"The physician is a servant, not a teacher of Nature."

"The physician should benefit or at least not injure."

He was not prejudiced nor devoted to a stereotyped system:

"We should examine also the strength of the sick, to see whether they may be in condition to maintain a spare diet to the crisis of the disease."

"Complete abstinence often acts very well, if the strength of the patient can in any way maintain it."

"In the application of these rules we must be always mindful of the strength of the patient and of the course of each particular disease, as well as of

the constitution and ordinary mode of life with respect to both food and drink."

In hygienic matters Hippocrates advises one to observe what he tolerates well and what badly, and to manage accordingly; to labor, rest, sleep all in their due season; not to eat too little nor with too absolute regularity, that deviation from the rule may not produce harm; to drink pure spring-water, as well as wine mixed with water more or less, according to the season; occasionally to get a little tipsy, so that accidental excesses may not occasion harm.

Among his numerous remedies (265 have been enumerated, in spite of his constantly emphasizing the assistance of Nature) Hippocrates employed chiefly vegetable substances, though drugs derived from the animal kingdom also were not discarded. Some of these remedies were also articles of food—*e. g.*, the flesh of the horse, ass, fox and dog, cabbage-juice, seven pints of ass' milk as a mild purgative. Metallic remedies were also recognized, such as copper, alum and lead.

The anatomical knowledge of Hippocrates was very imperfect, as must naturally have been the case, inasmuch as it was based upon the dissection of animals only. The different parts were not kept distinct enough from each other, but were often interchanged, intermingled and artificially constructed. In detail the bones were best known, while misty views alone prevailed with reference to the muscles. The intestines were fairly well distinguished. Nerves, sinews and ligaments were confounded together, while as regards the vessels (which contained partly blood and partly pneuma), and especially as to their course, his views were most singularly artificial. He was acquainted with the pericardium, the two ventricles, the thickness of the walls, the muscular nature and internal appearance of the heart; he knew that the left ventricle is empty after death, and he was acquainted with the valves of the great vessels of the heart. He also knew that the auricles do

not contract exactly contemporaneously with the ventricles. Four pairs of vessels were assumed, one originating behind from the nape, a second out of the head behind the ears, the third from the temples, the fourth from the brow.

The brain he regarded as a gland which condenses into mucus the ascending vapors, which then flow down through the nose. The kidneys are also glands, connected with the bladder by "veins." The liver is an organ for the preparation of blood and bile, has five lobes and is more vascular than all other parts. The vena cava with several bronchia pass from it to the heart and one vein goes from



Fig. 3—GREAT PHYSICIANS OF ANTIQUITY

it to the spleen. Hippocrates was acquainted with the duodenum, the colon, the mesentery, the seminal vesicles and the rectum, but no clear description of them is given anywhere. The nerves are hollow and convey the 'spiritus animalis' throughout the body, an idea which occasioned lively discussion as late as the seventeenth century.

Of physiology in the works of Hippocrates it is not easy to speak with propriety. Still the facts may be adduced that it was assumed the food was cooked in the stomach, which possessed a peculiar warmth, increased by

the liver; that the blood is "warm" in the left heart, while in the right it is still "cold"; that the cause of its warmth is the *pneuma*, received from the air by means of the "cold" lungs. Hippocrates' profound comprehension and appreciation of the history of medicine is expressed in the following maxim:

"The physician must know what his predecessors have known, if he does not wish to deceive both himself and others."

The undying importance of Hippocrates in medicine rests, first of all, not so much upon his enrichment of science with new material (though this honor too is his unquestioned due) as upon the creation of a scientific medicine and art; upon the method and really great principles which he introduced for all time into science and especially into practice. His investigation and determination of the phenomena of disease and of the science of etiology, and still more his improvement of professional treatment, have also won for him immortal reputation.

Hippocrates was above all else a practitioner who desired chiefly not to impose upon his fellow-men with showy discoveries and theories, but to assist them to the utmost of his power. And this he did. Hence his words of immemorial value:

"Where is love for art, there is also love toward man."

This maxim alone would raise him to that genuine humanity often ascribed to Christianity alone.

The great philosopher Plato (429 B. C.), perhaps one of the loftiest intellects the world has ever seen, and who illumined with his clear-sighted logic every subject he touched, treated in his philosophy certain points which had a distinct influence on medical thought for centuries to come. He taught that the heart is the origin of the blood vessels, and, as the seat of the mind, receives through them the commands of the superior soul. The lungs, which

receive through the trachea a portion of the drink in addition to the air, serve to cool off the heart. The liver serves the lower desires and is for the purpose of divination. The spleen furnishes an abode for the impurities of the blood. The intestine is long and tortuous, in order that the food may remain the longer therein, so that the mind may not be disturbed too often in its contemplation by the renewal of nutriment necessitated frequently by greater shortness of the gut.

Breathing, he declared, takes place by inward pressure of the air, for no vacant space can exist in the body. The muscles, with the bones, serve as a protection to the marrow against the heat and cold. The marrow itself consists of triangles, and its most perfect portion is the brain. Death is occasioned by a separation of the soul from the marrow. Sight originates in a union of the light flowing out of and into the eyes; hearing in a shock of the air (correct even now), which is communicated to the brain and the blood and even to the soul. Taste is due to a solution of rapid atoms by means of small vessels, which latter conduct these from the tongue to the heart and soul; smell, however, possesses no image as its foundation and is therefore very transitory.

Disease, he thought, originated in a disturbance of both the quantity and quality of the fluids. The most frequent cause of disease is the downflow of mucus and acidity; the most dangerous is corruption of the marrow. Another cause is the yellow and black bile, through whose aberrations inflammations arise. Continued fever is occasioned by fire, quotidian fever by air, tertian fever by water, quartan fever by earth. Mental diseases are the result of corporeal evils or of bad education. Besides bodily exercise and diet, remedies are formed from drugs, which constitute an opposing treatment for diseases, before which they flee away. Of physicians he says that they must be rulers of the sick, in order to cure them, but they must not be money-makers.

Praxagoras has acquired immortal fame by his discovery of the distinction between arteries and veins, of which the former were the active agents in the formation of the pulse. He thought, under ordinary circumstances, they contain air only, but in the case of wounds blood is also found in them, having been drawn in from all the surrounding parts. He considered respiration an action designed to strengthen the heart by forcing air into that organ; the brain was a mere dependence of the spinal cord, but the heart was the origin of the nerves. Praxagoras was a "humorist" of the purest water, and as such assumed no less than eleven humors: the sweet, acid, salt, bitter and pungent among them. He sought the source of fever in the great vena cava, and called attention to the differences of the pulse in conditions of health and disease. He practised taxis in every possible way in cases of strangulated hernia and even performed the operations of herniotomy and amputation of the soft palate when diseased. In therapeutics he favored bleeding, though only before the fifth day in inflammation, employed vegetable remedies almost exclusively and laid great weight on the diet.

Plato's greatest disciple was Aristotle (384 B. C.), who was—and indeed still is—an oracle in philosophy and in certain earlier elements of natural science. Having been given eight hundred talents (an enormous sum) for the collection of materials for a "history of animals," he expended it so wisely that he gathered into his own hands almost every item of information possessed by the ancient world. In advancing the knowledge of Nature and insisting on the exactitude of observations, he did more for medicine than even his master Plato. He assumed five elements as the component parts of the body and assigned to them three cardinal qualities: form, substance and motion or rest. Experience, he taught, was the basis of all science; the body is the instrument of the soul, and both body and soul are in essence one and the same. Life is

movement; the heart, however, is the seat of warmth, the source of motion, sensibility and desire. It is the "Acropolis of the body."

The investigation of Aristotle in natural science extended especially over the animal kingdom. He was a famous zoölogist and the founder of Comparative Anatomy. It is only through Physiology that he comes into contact with medicine, since pathology, particularly that of man, is only slightly and incidentally considered. He refers diseases to the blood and the humors, through the abundance or lack of which, as the case may be, their difference arise. He made observations on the influence of the weather, the season, the food, drugs, etc.

On the other hand, his labors in Anatomy, which he studied in animals, are of great importance. He distinguished the nerves as such, but called them canals of the brain, which latter organ he described as bloodless and of the largest size in man. Yet by the term "neura" he understands tendons and ligaments, which he thinks originate from the heart. He recognized the optic nerve, but explained the auditory nerve as a "vessel."

The common origin of the vessels from the heart is also one of his theses, and he discovered independently the difference between arteries and veins. He gave its name to the aorta and speaks of the great vena cava. Yet he had totally incorrect views concerning the course of the vessels. Thus one ran from the liver to the right arm, another from the spleen to the left arm; hence venesection upon the side of the organ affected by disease was especially efficacious. He described the ureter correctly and the organs of sensation inexactly.

In his Physiology he assumes that vessels and tendons preside over sensation. Chyle originates in the process of coction in the stomach and is thence carried into the heart. In his view the blood is the nutritive material designed for the formation, growth and warming of the body and for the supply of its waste. It is brought to the tissues by the

vessels and in its normal condition is an indifferent fluid which contains neither mucus, bile nor water. But in conditions of disease the blood becomes mixed with these extraneous fluids. Sleep is a restrained energy of sensation, with unrestrained capacity therefor. In respiration the *pneuma*, which serves for the purpose of cooling, passes through the trachea into the heart.

Aristotle emphasizes the necessity and advantage to the physician of a knowledge of the natural sciences. He says:

"It is the business of the naturalist to know also the causes of health and disease. Hence most naturalists see in medicine the conclusion of their studies, and of physicians, those at least who display some scientific knowledge in the practice of their art, begin the study of medicine with the natural sciences."

He also emphasizes the fact that the better class of physicians lay great weight upon anatomy. Yet in spite of his nice knowledge of Nature, Aristotle was not free from the superstition of his age and was a believer in dreams, the happy significance of a sneeze, chiromancy and similar matters which are now set aside.

The school of Alexandria (300 B. C.) presented an entirely new aspect to the ancient world. The science of medicine was cultivated in this school with great zeal, and some improvements are due to its professors. Among the most famous of these are Erisistratus and Herophilus. Little detail is handed down about them, but they are particularly mentioned as being the first who dissected the human body, for which purpose the bodies of criminals were allotted to them by the government. They pointed out the difference between the structure of the human body and that of animals which most resembled it. They ascertained more correctly the structure of the heart and great vessels and of the brain and nerves.

Soon after the establishment of the Alexandrian school

the medical profession became divided on the method of treatment and study of disease—the Dogmatists and later the Empirics. The Dogmatic school professed to set out with theoretical principles which were derived from the generalization of facts and observations and to make these principles the basis of practice. Although this is now considered the correct method to pursue the study and practice of medicine, it is a method which if not carefully watched is exposed to the greatest danger of being corrupted by ignorance and presumption. This occasioned the slow formation of the opposing sect—the Empirics—who defended the principle of ‘experience’ as being of chief importance in the development of the methods of medical investigation and treatment. The Empirics rejected as useless all search after the theoretical causes of disease and all knowledge of anatomy—certainly a grave mistake—but, on the other hand, in their emphasis on experience caused the formation of the conception of the physician, not only as a scholar and a student, but also as a man of ripe judgment and understanding.

CHAPTER III

THE ROMANS

FOR some centuries the Alexandrian school first contributed to the advance of all sciences and then prevented a too early decay of them. The Grecian civilization had begun to decline, and it was during this time that the Roman Empire laid the foundation for its future grandeur. The martial character of Roman life drew the attention away from medicine. "The Roman people," says Baas, "for more than six hundred years were not, indeed, without medical art, but they were without physicians."

This art consisted merely in prayers, dietetic measures, prescriptions from the Sibylline books, charms, etc. That the Romans cherished much grosser superstitions than the Greeks is well known. With rude simplicity they elevated into divinities those evils which especially harassed them and then in the early centuries of Rome worshiped these deities with fervor. Later Romans became dissatisfied with their own gods and worshiped also Phrygian, Egyptian and Grecian medical gods and built for them temples at Rome and in other places.

A Roman of natural talents, educated at Alexandria, acquainted with human nature and possessed of considerable shrewdness and address was Asclepiades (100 B.C.), but he possessed little science or professional skill. He began by villifying the principles and practices of his predecessors, especially Hippocrates, and asserted that he had discovered the most perfect and efficient form of treating diseases.

He conceived matter to consist of extremely small atoms,¹ cognizable indeed by the understanding but not by the senses.

Between the particles of the atom he suggested little empty tubes, the 'poroi,' in which move a multitude of the finest particles which occasion sensation and correspond to the pneuma of others, here considered only atomically. If the motion of these particles is quiet and regular, it is called health, but if it is irregular, feeble or boisterous, sickness arises. Sickness also originates in the air received in respiration and in the food and enters the body in respiration and digestion, by both of which it passes through the 'poroi' into the heart and the blood and through this finally into the whole body which it nourishes. The pulse originates in an influx of the particles into the vessels; animal heat, sensation, secretion in a similar way; hunger and thirst, however, originate in emptiness of the pores of the stomach, which, in accordance with varying conditions, may be either empty, full or contracted. According to him, the proximate cause of disease is stagnation of the atoms; on the other hand, he finds in the humors only a secondary cause.

In surgery Asclepiades has won great reputation by his practice of tracheotomy in angina. He also recommended scarification of the ankles in dropsy, as well as paracentesis with the smallest possible wound. He observed, too, spontaneous dislocation of the hip-joint.

In pathology he was the first to distinguish definitely acute and chronic diseases (for example dropsy). The special forms of diseases are based upon the greater or less disproportion of the atoms to the 'poroi' and the grade of stagnation thus occasioned. Thus, he said, quotidian fever originates through the largest atoms, tertian through the medium-sized, quartan through the finest.

Upon the size of these atoms depends also the grade of the fever; larger atoms occasion severe, smaller less dangerous fever. Fever heat originates in active movements

of the atoms; the chillness is due to their quiescence. Hemorrhage is a result of putridity or of laceration. Crises, in opposition to Hippocrates, Asclepiades totally denied, a denial which excited the special wrath of Galen. What is said in therapeutics of the activity of nature is, according to Asclepiades, pure sophistry. The physician alone cures and nature simply supplies opportunities.

Those who followed Asclepiades formed a new school, called Methodism, which stood for a course midway between Dogmatism and Empiricism. The theory was that the solids are the seat and cause of disease, in this respect directly opposite to that of Hippocrates, who traced cause of disease to a disturbance of the fluids, the so-called humoral pathology.

The most important Roman author on medical subjects and a compiler of a very high order in his eight books, "De Medicina," was Aulus Cornelius Celsus (between 25-30 B.C. and 45-50 A.D.). He had also written on philosophy, oratory, jurisprudence and history and was in fact an encyclopedist. Tho not a physician by profession, he thought and wrote on medicine as tho he were a practitioner, so that his work may claim the value of an original treatise on medicine.

His descriptive and operative surgery (including also operative dentistry) is considered his best contribution to medical art. It must still be regarded as a "masculine" branch in comparison with the salve-surgery which came into vogue at a later period. It gives also the best idea of the eminent services of the Alexandrians, who furnished the substance of surgical art.

He was the first writer who professedly treats of surgery and its operations, and he shows that the art had attained an astonishing degree of perfection. The state of surgery in his time must have been much further advanced than medicine.

He describes, on the one hand, a large number of surgical ailments, such as diseases of the joints and the bones,

wounds, tumors, burns, fistula, abscess, sprains and luxations, for which he recommends reduction before the development of inflammation; fractures, in which, when they fail to unite, he recommends extension and rubbing together the ends of the bone and even cutting down upon the bone so that it heals as an open wound; hernia, which he thinks originates in laceration of the peritoneum; strangulated hernia, where he cautions against cathartics; the radical operation for reducible hernia; foreign bodies in the ears, etc. On the other hand, he notices many operations of the ancients, some of them handed down by him alone, among others, bleeding, double ligation of bleeding vessels and division of the vessels between the ligatures.

In this work of Celsus much of the substance of the lost writings of ancient physicians, and especially those of the Alexandrian age, is preserved. He has manifestly selected from these with ripe judgment only what is reasonable, useful and valuable, and accordingly has paid comparatively little attention to opinions and theories, a point in which he contrasts strongly with Galen, and which impresses upon his work the stamp of practicality and usefulness.

Celsus is the first native Roman physician whose name has been transmitted. Before his time all those who arrived at any degree of eminence were either Greeks or Asiatics, thus suggesting the idea that most native practitioners were of humble rank. This may be attributed to the low state of science in Rome, altho literature had advanced to a high state. All trades and manufactures of Rome were carried on by slaves, and medicine seems to have been placed in the same class.

In opposition to the humoral theory of the "Dogmatists" and the solidism of the "Methodists," the Pneumatic school introduced the aeriform, spiritual principle of the "pneuma" (the world-soul of the Stoics), into their general pathology. Yet they also left the elementary qualities (warmth, coldness, moisture and dryness, which according to their doc-

trine may be seen and felt and not recognized simply by their effects) a place in their "system." The pneuma comes by way of the respiration as a part of the creative "world-soul" into the heart and is driven thence into the vessels and the whole body, in which it effects in a passive way the diastole of the pulse, while the contraction of the arteries is an active process. When it works regularly and is united with warmth and moisture it occasions health; under contrary circumstances, and mixed with warmth and dryness, it occasions the acute diseases, while mixed with cold and dryness melancholy. This latter condition in its acme introduces death, a state in which everything becomes dry and cold.

Areteus of Cappadocia (about 30-90 A.D.) shows himself a great physician by his conception, even thus early, of the duties of his profession. He was one of the Pneumatic school and an eminent medical writer.

In anatomy he does not differ greatly from the views of his time. Still in his work are found intimations of the tubes of Bellini, while he may have had a correct idea of the decussation of the nerves in the medulla. He knew that the tongue was composed of muscles. In physiology he, with Aristotle, regarded respiration as the process by which the pneuma reached the lungs and thence the heart, the seat of life. The blood was prepared in the liver, the bile in the gall-bladder; in the large intestine a secondary digestion takes place; in the spleen is to be found thick, coagulated blood; the seat of the soul is in the heart. He knew that the contents of the arteries was light-colored, that of the veins dark.

Rufus of Ephesus (about 50 A.D.), who lived shortly after Celsus, practiced dissection on apes and other of the lower animals. He discovered the decussation of the optic nerves and the capsule of the crystalline lens and gave, for the time, a very clear description of the membranes and parts of the eye. He taught that the nerves originated from the brain. Physiologically he divided them into

nerves of motion and nerves of sensation and ascribed to them all the functions of the body, since he did not distinguish them accurately from muscles and tendons. The heart, whose left cavity he declares to be thinner and smaller than the right, he considers the organ which gives origin to the pulse, and he associates the latter also with the pneuma. He describes the pulse carefully in its vari-



The Eclectic school was founded 90 A.D., the main principles being to avoid theories and metaphysical speculations and to select from all preceding schools that which was most reasonable and practically beneficial. The most famous man of this sect was Claudius Galen (131-204 A.D.), one of the most remarkable men in the whole history of Medicine. He made his influence felt both in his time and for centuries to come. He enjoyed a most thoro education at home and abroad; he studied at Alexandria and traveled extensively; he knew all the teachings of his predecessors and he wrote an immense number of medical treatises. At once he attained first rank in medicine, and this rank has been compared not unaptly to that which Aristotle possessed in the world of general science. For centuries after his death his doctrines and tenets were regarded almost in the light of oracles which very few had the audacity and courage to oppose. And it may be stated without exaggeration that the authority of Galen alone was estimated at a much higher rate than that of all other medical writers combined, extending over a period of twelve hundred years.

That he was a man of wonderful intellect and great talents no one can deny. He had studied philosophy very thoroly, and as was the tendency in those days, this was intimately interwoven with his medical beliefs. He was an admirer of Hippocrates and always speaks of him with great respect, professing to act on his principles. Yet, as a matter of fact, the two men could not be more different, the simplicity of the ancient Greek being strongly contrasted with the abstruseness and refinement of Galen.

The general pathological views of Galen are founded upon the four elements to which are attached the primary qualities: To air coldness, to fire warmth, to water moisture, to earth dryness. To these correspond four cardinal humors, among which latter the element water predominates in the mucus, which is secreted by the brain; fire in the yellow bile, which has its origin in the liver; earth in

the black bile formed by the spleen, while in the blood, which is prepared in the liver (an important error not discarded until the seventeenth century), the elements are uniformly mixed. Mucus is cold and moist, yellow bile warm and dry, black bile cold and dry, the blood warm and moist.

The life-giving principle is the soul, which as "spiritus," or "pneuma," is taken from and constantly renewed by the general world-soul in the respiration. Arrived in the body, the pneuma becomes in the brain (to which it penetrates through the nose) and in the nerves the "animal spirits"; in the arteries and the heart (to which it comes by way of the lungs) the "vital spirits," and in the liver and the renal veins the "natural spirits." The three fundamental faculties, the "animal," "vital" and "natural," which bring into action and keep in operation the corresponding functions, originate as an expression of the primal force "soul" (pneuma), existing in these three faculties within the body. Besides these, there are for special functions of the body other faculties, subordinate to these three and acting occasionally as the "attractive," the "propulsive," the "retentive" and the "secreting."

Upon these depend nutrition, assimilation, secretion, muscular contraction, in general all the ordinary functions of the body, in which each organ has the property of appropriating to itself, by means of these faculties, that which is necessary for its own existence. There are, besides these, "special forces," which are not derived from the three already named, and which are therefore supernatural. Everything, however, which exists and displays activity in the human body originates in and is formed upon an intelligent plan, so that the organ in structure and functions is the result of that plan. Thus the human frame is adapted to the solution of a teleological problem. Indeed Galen is the father of teleology in medicine.

Galen is of peculiar importance in special pathology from the fact that he first designedly employed experiment

for its basis. He was the first physiologist (if we except the accounts of the Hippocratists in embryology) to experiment and vivisection upon scientific principles and founded the physiology of the nervous system. Nerves of motion, which as such are "hard," are represented by the sixty spinal nerves; those of sensation ("soft") by the nerves of the brain. Of the latter he recognized seven. Galen was acquainted with the movement of the brain and assumed that by it the impurities of the "animal spirits," brought to the brain by the carotids, were then expelled, while its more refined portions, the nervous spirits, were prepared in the plexus of the ventricles and thence borne by the nerves throughout the body. The great sensibility of the intestines depends upon the sympathetic nerve. The perception of light he locates in the retina.

Respiration and the pulse serve one purpose—the reception of air. The latter in inspiration comes first into the lungs and thence into the left heart and arteries. On the other hand, during the diastole, or rest of the arteries, air is sucked into them through the pores of the skin. During the systole, or contraction of the lungs and arteries, the "soot" escapes. The air or *pneuma* received by the lungs is not sufficient by itself to cool the heart, hence air is also received through the skin. The diastole of the heart and arteries and inspiration also conduct *pneuma* to the blood, while the systole and expiration discharge the "soot" from the blood. Respiration has its origin in the vital, the pulse in the animal sphere. Respiration is effected by means of the diaphragm and the intercostal muscles.

The physiological route of the *pneuma* (the respiratory process he deemed one of combustion) is developed within the body or the vessels as the circulation, which takes place as follows: From the stomach the food, which has undergone "coction," proceeds to the liver, where it is converted into blood. This blood is now carried to the heart, and the latter organ (whose various parts all con-

tract simultaneously) drives into the lungs, through the pulmonary artery, so much of this blood as may be required for their nutrition. At the same time the remainder of the blood is driven through the veins into the body and a minute portion passes through the pores of the septum into the left ventricle, where it is mixed with the pneuma drawn into the heart through the pulmonary veins in diastole. No blood returns from the lungs to the heart, for all of it is consumed in the nutrition of those organs. From the left heart the blood (mixed with the pneuma) proceeds through the aorta, to be communicated to the veins finally by means of the pore-like anastomoses at the terminations of this vessel. To the veins all the nutrition of the body is due.

The blood conveyed to the body by the veins is principally used up in nutrition, but what little remains, together with the new blood formed in the liver, returns to the right heart by a sort of ebb-tide in the venous circulation. Dilatation and diastole of the heart, as well as of the arteries, are the active factors in the motion of these parts, while systole is the passive element. (Systole is really the active heart-muscle.) Singularly enough, however, no physician, down to the time of Harvey, formed a similar opinion of the theory of circulation of the ancients. The blood is perfected in the heart and supplied with the 'calidum innatum' (innate heat) and then passes on into the body. The pulse arises from an active dilating force, pulse-force, communicated to the arteries from the heart.

The heart has no nerves, but is the seat of passion and courage. The brain is the seat of the rational soul and an organ for the secretion of mucus and for cooling the heart. The lungs also serve to cool off the heart. The liver is the place for the preparation of the blood and the seat of love. The "animal spirits" are the cause of the soul's activity. They originate from the blood, but in the brain become the "animal spirits." From the origin of the "animal spirits" the dependence of mental expressions and disturbances upon the bodily condition is also explained.

Galen divided these mental disturbances into mania, melancholia, imbecility and dementia.

In direct opposition to what had been said concerning mental activity and its cause and seat, he explains the temperaments by the mixture of the elements, and therefore divides them into (1) the dry and warm (choleric); (2) dry and cold (melancholic); (3) moist and warm (sanguine); (4) moist and cold (phlegmatic). The sensations again are dependent upon the animal spirits. The sight is effected through that portion of these spirits which is found between the lens and the choroid and which intercepts the rays of light in order to conduct them to the optic nerve. The pneuma likewise occasions the smell by forcing its way into the anterior ventricles of the brain, which are the seat of this sense. The hearing originates in the penetration of the pneuma, in the form of waves, into the course of the nerve of hearing.

Much more original is the knowledge of Galen in anatomy, which from his youth up he studied with enduring fondness. His observations were confined entirely to the lower animals, except in regard to the bones, which he had been able to study upon two human skeletons at Alexandria. One of these skeletons had been cleaned by birds, the other by the Nile, and Galen considered it a piece of special good fortune that he had been able to study their structure. His anatomical works—the best among the ancients—continued text-books down into the sixteenth century. He is in many points the first discoverer and always a very careful describer, the latter especially in regard to osteology, the central and peripheral nervous system, the larynx, the intestines and the genital organs, tho he, too, is not free from the confusion and errors of the ancients and readily falls into teleological speculations. He handled the subject of bandaging in detail and introduced the methods known even to-day.

Galen did not greatly advance semeiology, with the exception of the doctrine of the pulse, which he elaborated

so extensively that he wrote many treatises on this subject alone. He advanced diagnosis chiefly by his sharper systematic definition of the phenomena of disease, while, so far as the means of investigation are concerned, he did not go beyond the Hippocratists and earlier physicians.

In special pathology Galen added little of importance to the material already existing, tho he constructed his pictures of disease more perfectly through a better analysis of single symptoms, as in phthisis (its different forms and infectious (?) character), pneumonia and pleuritis, gout, rheumatism, intermittent fever, varieties of spasm, etc. Cancer he regards as a parasitic being, which occasions both local and general disturbances. Rightly, however, he laid great weight on so-called climatic cures, of which he seems to have been the founder. But even in the treatment of disease he was less a practitioner than a skilful theorist.

One of the most distinguished surgeons of antiquity was Antyllus, the first who, in addition to depression, described the extraction of small cataracts. He also described the so-called Antyllic method of operation on aneurism, as well as the method of practicing venesection, cupping, scarification, arteriotomy, subcutaneous section of the ligaments in stiff joints and of the ligaments of the tongue in stammering.

The change which came over the world of thought with the transference of the capital from Rome to Constantinople was not without its effect on medicine, and from the time of Antyllus a new type of medical art is made evident. Naturally the Roman period followed the Greek in its much philosophizing, but there was an earnest desire to learn and what was known was practiced simply and without the desire to impress the beholders. The periods to come reveal a vast change in the attitude of the medical profession to the world, the classic medical philosopher disappearing with the fall of Rome.

CHAPTER IV

BYZANTINE AND ARABIAN SCHOOLS

WITH the removal of the "Capital of the World" from Rome to Constantinople (Byzantium) a new epoch was opened upon the world, in which Medicine shared. Constantine I. (312-337), the first Christian emperor, seemed to feel that by investigating theological claims he had secured exemption from scientific interest, and the healing art found little imperial patronage. Indeed, the times generally seemed to be satisfied with the progress that had been made in science, and after the death of Galen, for many years there are no illustrious names, and no discoveries worth the mentioning. Literature had declined rapidly, and the last vestige of Roman patriotism passed away when the empire was divided into an East and a West. Even in the time of Galen, the Roman Empire had begun to decline, and altho it produced a very few scientists, most of the illustrious physicians and surgeons were foreigners—either Greeks or Asiatics. But during the third and fourth centuries of the Christian era, no names are heard, nothing is written—there being merely a few compilations of Galen and the early Greek physicians. One of these compilers, perhaps the best, was Oribasius, who at the request of the Emperor Julian, made a compilation of all medical works from the time of Hippocrates to Galen.

The city of Alexandria still retained its reputation as the great school of medicine, depending, of course, on its ex-

tensive medical library. But this was destroyed by the conquest of the Arabians in the seventh century. The Saracens, in a spirit of blind bigotry, appeared to be actuated by the barbarous desire to eradicate science from the face of the earth. However, in spite of the Saracens, some of the books escaped the fire, and these were carefully hidden by those who appreciated their value. Among these relics were the writings of Galen, and in an early period of the Saracenic Empire, they began to be held in high esteem. This period extended only to the eighth century and was merely a continuation of Galen's wonderful influence. The physicians did not advocate science, merely professing to comment on and copy from the works of their great master.

Aetius (circa 510 A.D.) occupied in Byzantium almost the same position as Oribasius in Rome. He embraced the doctrines of the Christian religion, and these played some part in his treatment of diseases. In surgical therapeutics, Aetius recommended a great number of salves and plasters. The preparation of salves must, however, take place with certain ceremonies. Thus, one should continually repeat, in a loud but solemn tone, the charm "The God of Abraham, the God of Isaac, the God of Jacob, give virtue to this medicament," until the required consistency of the plaster in process of making is obtained. If a bone is stuck in the throat, the patient should swallow, and then draw out again, a piece of raw meat, to which a pack-thread has been fastened; or the physician should grasp him by the throat (unfortunately the results of this treatment are not given!) and cry in a loud voice, "As Lazarus was drawn from the grave and Jonah out of the whale, thus Blasius, the martyr, commands, 'Bone, come up or go down!'" He practiced venesection on both the diseased and the sound side, and in cerebral congestion advises also a stick to draw into the nose of the patient, that the double hemorrhage may render the cure more certain. He further commends the pimper-

nel in hydrophobia, and pomegranate bark for worms. To detect poison in a wound he makes use of a poultice of walnuts laid upon it and afterward thrown to a fowl; if the fowl eats the poultice, the wound is free from poison; if not, it is not.

Aetius defended the Hippocratic maxim that Nature should be permitted to have her own way, a precept to which very different explanations have been given from Hippocrates' time down to the present day, since it is usually "the masters' own nature" which they ask others to follow. In hectic fevers he advises nutritious food; in febrile diseases generally, coolness of the apartment. Typhoid fever manifests as its chief symptoms stupor and delirium, febris algida, however, an icy coldness.

His doctrine of fever, according to which the seat of fever is in the heart, is most complete. Fever results chiefly from diseases of the stomach and intestinal canal. The general vitality suffers in diseases of special organs only so far as it functionates through these organs. On mania and diseases of the mind in general he makes some admirable observations. His methods of diagnosis are comparatively perfect. Thus he employs the pressure of the fingers for the detection of anasarca (the frequent inflammatory nature of which, indeed, he first recognised); palpation in enlargements of the spleen; inspection in the investigation of urinary sediments, which he discusses fully; percussion in tympanites and succussion in ascites.

The diseases occasioned by worms he describes very well, and he also recognises lung-stones, so that he had evidently made dissections. His views on the place where venesection should be practiced give evidence of a freedom from prejudice far in advance of his time. He bled from all parts of the body, and held the opinion that it was perfectly immaterial whether the operation was performed in the vicinity of the diseased parts (as Hippocrates preferred), or (as the Methodists directed) on the opposite side, since all the veins in the body communicate. He

admonishes his colleagues not to be dazzled by the glare of "The Authorities."

In striking contrast with these and similar sound principles, however, are his peculiarities and his superstition, in which qualities he was a true son of his time. Thus in gout he recommends a very complicated antidote, the use of which is to be begun in January, and continued for a year and a day. It is to be taken 100 days, then suspended for 30 days, then resumed for 100 days, then suspended 15 days, then it is prescribed again every second day for 260 days, after which 80 similar doses follow. He cures the pains of colic by a stone, upon which is engraven the figure of Hercules strangling the serpent, or by an iron ring, upon one side of which is exhibited an incantation, on the other, the diagram of the Gnostics.

Theophilus (circa 540 A.D.) was one of the most popular physicians and medical authors during the Middle Ages, and his work, 'On the Structure of the Body,' was often made the basis of instruction in the universities. In it, among other things, the olfactory nerves are first mentioned as a special pair of cerebral nerves; attention is directed to the dependence of the development of the skull and vertebral column upon that of the brain and spinal cord, and reference is made to how the wisdom and goodness of the Divine Being have ordained everything so infinitely perfect as to give to the hand precisely five fingers, and to the skull a spherical form. In general he follows Galen.

Paul of Aegina (circa 560 A.D.) was the last of the Greek physicians who were of any rank in medicine. The military surgery of Paul is very complete, clear, and suited to the weapons of the period. It is evidently based upon a rich experience, for he had seen even the worst injuries do well, and in operations he desires, above all, that the wounded part should occupy the same position which it had occupied at the moment of injury. In order to remove sling-stones, darts, arrow-heads, etc., he cuts or draws them

out or pushes them through, and he gives judicious precautions to avoid the injury of any important parts.

Pathology he treats from head to foot, after the method customary in his day. He also describes specially diseases of the skin and heart (without, however, differentiating the individual diseases), epidemic colic, and ascribes gout, very properly, to an inactive life, with too rich food.

From the foregoing it may be inferred that Paul must have been one of the most capable, if not the most daring operator of his age. His experience in this department of the healing art, and particularly at this time, seems the more surprising, since for centuries before him, surgeons had made shift with an apparently inoffensive surgery of plasters and salves, rather than resort to operative measures.

After the destruction of the Alexandrian library and its medical contents, the Arabians turned to Grecian science for instruction in the medical arts. They followed Hippocrates and Galen, translating them both into Arabic. The works of Hippocrates did not obtain much hold, however, on account of the simplicity of this author, whereas the metaphysical refinements and elaborate arrangements of Galen pleased the Arabic taste. After the conquests, the successors of Mahomet rested, and seemed disposed to add to their grand empire by the cultivation of the arts of peace. They even translated the Greek philosophers and studied them. But in spite of all this, they were not open to this form of intellectual advancement, and no additions were made to general science, other than the invention of chemistry or alchemy. They even introduced it into medicine.

Among the special medical branches, practical anatomy was utterly excluded by religious belief, and midwifery and gynecology were then (as almost in the East to-day) forbidden to men. The practice of operative surgery, too, was considered unworthy of a man of honor, and was permitted only to the despised lithotomists and similar per-

sons of the lower class, who in consequence of the fatalism of the Arabians (in spite of the remarkable tolerance of the Orientals, even to-day, for painful operations), were very rarely allowed to have recourse to the knife.

"Operations performed by the hand, such as venesection, cauterization, and incision of arteries," says a writer of this period, "are not becoming a physician of respectability and consideration. They are suitable for the physician's assistants only. These servants of the physician should also do other operations, such as incision of the eyelids, removing the veins in the white of the eye and the removal of cataract. For an honorable physician nothing further is becoming than to impart to the patient advice with reference to food and medicine. Far be it from him to practice any operation with the hands." Even the extraction of teeth was avoided, and, although dentistry was cultivated, as among the ancients, it was practiced only by the lower class of physicians, the assistants.

Medicine proper was chiefly taught. Chemistry, pharmacy and materia medica, and indeed, the history of medicine were also well cultivated. They were the first to describe smallpox. They greatly improved drugs, due mainly to their researches in chemistry.

Rhazes (932-1010 [?]) was a prolific writer, but blindly followed Galen. His most important additions to knowledge were in surgery and in pharmacy. His semeiology and prognostics, with the exception of the indications to be derived from the urine and the planets, are famous; yet his anatomical and physiological knowledge never exceeds that of Galen.

Avicenna in the tenth century wrote a work which contains substantially the conclusions of the Greeks, and was the text-book and law of the healing art, until modern times. It includes anatomy, physiology and materia medica. In it are mentioned camphor, iron in various forms, amber, aloes, manna and many other drugs. He considers gold

and silver as "blood-purifiers"; hence gilded and silvered pills are, in his view, specially efficacious.

His pathology makes prominent mention of mental diseases, and notices *tic douloureux* (described also by other Arabians), tetanus, three forms of inflammation of the chest—pleuritis, muscular rheumatism and mediastinitis—measles and the purples. He is also said (according to Leichtenstern) to have been the first physician to teach the contagiousness of phthisis. In his general pathology and therapeutics he distinguishes, among other matters, fifteen kinds of pain, and preserves the Galenic humoral pathology. In great coldness and in great heat he gives no medicines, and considers the same remedy good in one locality, which would be injurious if employed in another.

In surgery he calls the extraction of a cataract a dangerous operation, but speaks in favor of depression; declines to operate on strangulated hernia; describes puncture of the bladder; the method by which leeches and other foreign bodies when swallowed may be removed from the œsophagus, hardened wax removed from the meatus, etc., while he prefers to loosen the teeth by means of the fat of tree-toads, rather than to pull them out. In obstetrics he follows the views of the earlier writers. In military surgery (according to Fröhlich) he taught only very little, and this he borrowed from the Greeks, without giving his own experience.

Albucasis, later in the same century, is the last of the Arabian physicians to attain any distinction as a writer. His principal work is on surgery, and he was as famous as a surgeon as was Avicenna in medicine. He performs venesection, after the manner of the Arabians, upon the sound side and recommends the employment of the same with the view of prophylaxis, an idea from which subsequently originated a pernicious custom. Besides the surgical diseases already noticed from his treatise on operations, he recognises a gangrenous epidemic erysipelas, warty excrescences, fractures, which, after the manner

of his age, he rectifies by means of machines—a cruel procedure of which reminiscences still exist among the public. Plates of instruments adorn the work. He valued anatomy as an important aid in the practice of surgery. This was unusual and interesting in an Arabian. He was a bold operator and a man of keen insight. His work on surgery was the most complete of that time, and was used for years after his death as a text-book.

The celebrity of the Arabian school of medicine is based, not on its real merits, but on the fact that the surrounding countries were in a very much lower state of medical knowledge. From the eighth to the twelfth centuries was the period of Europe's most complete superstition in natural science. The principal remains of a taste for literature and science, or for the fine arts, were found among the Moors and Arabs; and it was from this source, by the intervention of the crusaders, and the intercourse which was thus effected between the Asiatics and Europeans, that the philosophical and medical writings of the Greeks were first made known to the inhabitants of Italy and France. For some time after their introduction into Europe, they were still translated from the Arabic, and it was not until much later that they were read in Greek. Inasmuch as the study of the Greek tongue was so completely suspended during the Dark Ages, it is possible that the writings of the ancient physicians might have been lost to posterity, if they had not been preserved in these Arabic translations.

There are two points in which the Arabians conferred a real obligation upon their successors—the introduction of various new articles into the *materia medica*, and the original description of certain diseases. The Arabian school is said to be the first to found a hospital in which medical students received clinical instruction. The menace of Saracenic power was real and terrifying to Southern Europe, its unchecked success might have been fraught with disastrous results to civilization, but at least the very nearness of the peril led to the acquisition from the Orient

by the Occident of the elements of an almost forgotten learning.

After the extinction of the Saracenic school in Spain, there is an interval of about three hundred years, from the twelfth to the fifteenth centuries, during which time Europe was enveloped in scientific darkness. Every department of natural investigation was neglected, and medicine, as a science, fell into its lowest state of degradation. What remained was in the possession of the monks, who regarded knowledge as being useless unless it had some theological bent, and who desired to keep mankind looking ever to a future world and not to this. The practice of medicine, if such it may be called, was chiefly in their hands, and they adhered closely to the principles and practices of Galen. But mixed with these was a large portion of superstition, magic and astrology. By means thus employed, they gradually came to possess a profound influence over the minds of the people, and operated so powerfully on the imagination of their patients that their doings seemed almost supernatural.

It is certain, however, that there were, besides the monkish physicians, laymen who practiced medicine, but they held no such position as once they had. The lay physician was not looked upon as a learned man, for the latter was one who had been duly instructed in a monastic school, where the curriculum would not admit the art of medicine, wherefore the lay physician was considered as a mechanic or tradesman. Laws were enacted to restrain and govern these men, and they were made responsible for any want of skill, while the fee for any given piece of surgery or medical advice was stipulated.

In addition to the monks, there existed also many Jewish physicians, who had been educated at Alexandria, later in the Arabian school, and they were lay physicians of a high order. They attended princes and even popes, in spite of edicts of the Church prohibiting this very thing. The monks, however, held the highest place, which was

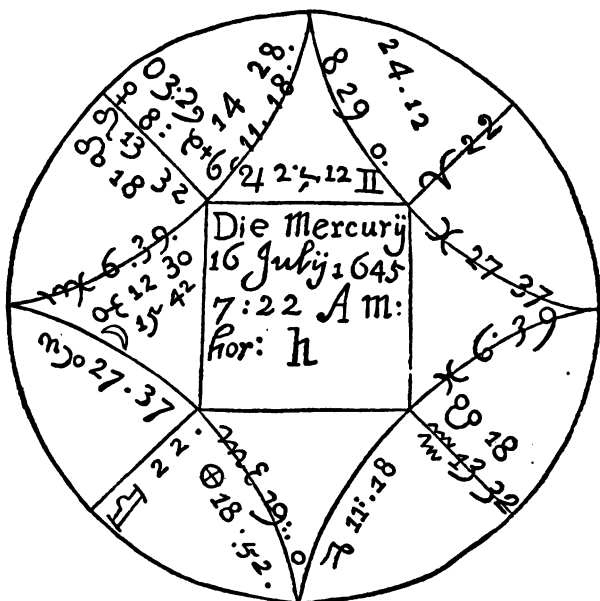


Fig. 5—AN ASTROLOGICAL DIAGNOSIS

"The signe ascending, viz., ♈, is in the figure most afflicted by the corporall presence of ♄, who is partly lord of the eighth house; therefore from that house and signe must we require the disease, cause, and member grieved. ♃ being the signe of the sixth, is fixed, afflicted by ♄; and ♋, who is lord of the sixth house, is in ♈, a fixed signe, earthly and melancholy, of the same nature and triplicity that ♈, the signe ascending, is of; the ♃ being a general significatrix in all diseases, being afflicted by her proximity to ♄, and posited in the ascendant in an earthly melancholy signe, together with the other significators, did portend the patient to be wonderfully afflicted with the spleen, with the wind-cholick, and melancholy obstructions, small feavers, a remisse pulse; and as the signe ♈ is the signe ascending, and ♃ and ♄ therein, it argued, the sick was perplexed with distempers in his head, slept unquietly, etc. [*All which was true.*] I perswaded the man to make his peace with God, and to settle his house in order, for I did not perceive by naturall causes that he could live above ten or twelve days"—(Lilly).

low enough to be sure, until the solid foundation of Salerno and the European universities. Yet there were many of the clergy, especially among the Benedictines, who studied the ancient physicians and were more worthy of the name. Under the direction of the Church, many institutions and orders sprang up. These had in view the helping of diseased and maimed mankind, and houses were used especially for their care and maintenance. The monks were restrained from malpractice by the orders of the Church. Their medical practices were theurgic to an extreme degree. Prayers, amulets and many superstitions were employed generally and openly for the cure of everyday diseases. Sickness was regarded as punishment from God, or a visitation from the devil (ideas by no means foreign to the present day). The monks held the principle of 'similia similibus,' and "treated the poisoning occasioned by swallowing a toad by directing the patient to eat another toad." The higher monks were first restrained in the twelfth century, and the practice of medicine forbidden them. Then, later, the lower monks were also restricted, and particularly all burning and cutting (surgery) were forbidden them on the principle: "The Church shuns bloodshed."

The Benedictines were the most scientific of the monks, and they cultivated medicine to a considerable extent. An excellent influence upon medieval medicine and its development was exercised by the monastic infirmary at Monte Cassino, and still more eminently and effectively by the school of Salerno. The former, founded by St. Benedict himself, was mainly for practice rather than instruction, and miracles were said to be performed here. The monks came from foreign lands to learn treatment and to study. The glory of Monte Cassino was displaced by Salerno, which attained its greatest position in the twelfth century. It held its prominence for more than a century,

Salerno was founded as early as 200 B.C. by the Romans, and because of its charming situation and climate, it en-

joyed a wide reputation as a health resort. It is probable, therefore, that physicians were always located there. After the establishment of Christianity, it became the resort for pilgrims, as well as a kind of medical resort. The dissection of a body was allowed every five years. This was allowed by Salerno's patron, Frederick II. The importance of Salerno as regards medical culture depends not on any wonderful contributions to science, but rather because the principles of the great ancients were preserved in the Greek itself, and also through Arabians.

The school of Montpellier was equally important in the culture of the West, for here, too, they studied the ancients, especially Hippocrates, and also the Arabians and Galen. The reputation of the school was so great that to have studied there lent a halo of glory to the monkish physician. They were liberal in viewpoint and demonstrated their practical scientific tendency by allowing the annual dissection of a criminal corpse (1376). About this time, other universities sprang up at Bologna, Oxford and Paris. These helped to start that reformation of thought which came later. The number of students speedily became very great, and often formed whole communities. The course of instruction in medicine was carefully watched over by the Church and subsequently by the State.

The great Hohenstauffer Frederick II., enlightened by the wisdom of the Orient, was especially active in the promotion of education, and above all, in the elevation of the position of physicians. He paid no heed to the triple ban of Pope Gregory IX. (1227-1241), and by his promotion of medical studies and educational institutions he became a benefactor of mankind, and especially of Italy. Through his medical ordinance, published in 1224, he has secured for himself forever an honorable place in the history of medical culture. Some of his reforms were of the nature of restraint and government of the practice of medicine. The surgeon must bring evidence that he had attended the

lectures of the professors, and pursued for one year the curriculum which surgeons held necessary, especially human anatomy. Surgeons of the first class were examined by three professors, of whom one teacher of surgery conducted the examination in the Latin language, and in the presence of the prosector of the nation of the candidate.

The foundation of the new universities did two things to further medicine; one was that medicine, its teaching and to a certain extent its practice, fell into the hands of men who were thinkers and learned, and the other was the introduction of the so-called scholastic philosophy. The teachings of the Greek physicians, and the elaborations of those teachings by the Arabs, were cherished as very gospel, and the physicians of the period made no effort to change or add to them. Aristotle's philosophy, combined with Arabian, extended up to the seventeenth century.

This period, better known as the Age of the Arabists, is characterized by the medical men, both clergy and laymen, following the Arabians in science and practice. There was one famous Peter Abano, who lived near Padua, who was a man of refined views, altho markedly superstitious. He wrote several books on science.

A circumstance which tended to shake the authority of Galen, and to diminish the veneration in which his opinions had been held for so many ages, was the rise of the sect of Chemical Physicians. After chemistry had been used with advantage for the purpose of improving pharmacy, it was applied to the explanation of the phenomena of vitality and of the operation of morbid processes upon the living organism. The theories of these chemists were false, but they served to divide the profession, and acted as a wedge in the downfall of Galen's long influence.

The revival of human anatomy in the fourteenth century was so great an epoch in the history of medicine that it marks the point of turning toward modern science. Commerce, business, manufactures and the higher arts were more and more cultivated, especially in Italy. In 1330,

the invention of gunpowder by Berthold Schwartz, so important in the history of civilization, was later the means of reforming surgery. Anatomy, in its practical human aspect, became an openly recognised department of medical science.

After the period of the Alexandrian anatomists, human anatomy, especially the practical portion of it, again had almost disappeared from the list of medical studies, though here and there probably a sort of dissection may still have been practiced. Even Galen dissected only animals, and he considered it one of the great advantages of Alexandria that human skeletons could there be seen. In the early Middle Ages the monks would have tolerated such a process quite as little as the Koran, feeling it to be an impairment of the capacity for resurrection, a belief still supposed to be involved in anatomical dissection.

How early, and where human dissections in aid of anatomical studies were revived, is unknown. This much, however, is certain, that the Senate of Venice (in spite of the prohibition by Pope Boniface VIII., eight years before) decreed in the year 1308, that a human body should be dissected annually. From this express decree it would seem to follow that this had already been often done heretofore. At all events, William of Salicet and others in Bologna had performed dissections. But, as a matter of historical fact, the credit of the revival of dissection belongs to Mondino alone, who took hold of the subject at the psychological moment.

Mondino de Luzzi was one of the first of this period, the fourteenth century, to write a treatise on anatomy and dissection of the human body. His work is written entirely in the spirit of the Arabians, and he followed Galen in describing the abdominal walls as being constructed without bony supports, in order to stretch sufficiently in cases of flatulence and abdominal dropsy, if perchance these diseases should befall one.

Mondino, to escape burdening his soul with mortal sin,

did not yet venture to open the skull, but others were less fearful, and investigations were soon so popular that bodies for dissection were stolen, if they could not be otherwise obtained. The description was read from the book, as the professor did not dream of soiling his fingers by actually handling the body. Mondino's work was designed to be such a text-book of anatomy, and it maintained general acceptance as such down to the close of the Middle Ages.

After Mondino, little further advance was made for two centuries in anatomy, but a general spirit of progress now manifested itself in the arts and other sciences; philosophy in all its branches was studied on a more correct plan, and medicine accordingly improved. One of the first symptoms of this improvement was the increasing relish for the writings of Hippocrates, and a revival of his method of studying and practicing medicine.

Probably as a result, first, of the influence of the Crusades, in which many wounds were inflicted and subsequently treated; second, of the revival of anatomy, many surgeons of this period were excellent anatomists. As a result of the invention of gunpowder and its application to instruments of war, the surgical wounds changed in character, requiring, in their treatment, a more thorough knowledge of anatomy. On account of these things, surgery advanced with great strides, and that in spite of the fact that it still remained in the hands of the lower surgeons who were originally assistants of the clergy.

In Italy, surgery remained united with the practice of medicine, and was practiced by all physicians who professed to be general doctors. It was always held in high esteem, both by the profession and by laymen in general, and never fell into the disreputable position that once existed in France. The surgeons of Italy were particularly clever in developing plastic surgery by the construction of artificial noses and ears. In France, on the other hand, surgery became entirely separated from medicine in the second half of the Middle Ages.

A class arose called "Barber Surgeons," because they shaved, and performed menial jobs of all sorts. They developed surgery very largely, forming themselves into a distinct profession, possessing a college of their own. Later they divided into guilds of "superior" and "inferior" surgeons, the former being subordinate to the latter, while both were under control of the physicians of internal medicine, called the Faculty. These surgeons, who were called "surgeons of the long robe," later formed a college, and separated themselves from the barbers, called "surgeons of the short robe."

Guy de Chauliac (1300) was one of the distinguished surgeons of early France. He showed wonderful comprehensiveness and judgment in his work, and in its description. His own observations of diseases, and his knowledge of anatomy were considerable. He used the thermocautery in treatment of cancer, which he declared was allied to leprosy. Non-ulcerating cancer he operated on and cut out from the roots. Operations on diseases of eye, and treatment of fractures, were well performed. He trephined the skull, performed lithotomy, and operated on nose and throat. Hemorrhage he divides correctly into arterial, or spurting, and venous, and his hemostasis consisted in modern methods of styptics, suturing, division of half-severed vessels, actual cautery and ligation.

During the fourteenth and fifteenth centuries formidable diseases made their appearance in Europe. Some of the causes were in part prolonged in their effect from the last days of antiquity, but the origin of others is still obscure. Among these one of the most remarkable was the *Sudor Anglicanus*, which is first mentioned about the end of the fifteenth century, and which for about fifty years raged at intervals with extreme violence in England and Western Europe. This disease, "English sweating sickness," as its name implies, was characterized by a severe sweating which consumed the strength of the patient, followed by terrible headaches, irregular heart action, delirium, stupor

and finally death, all in the short space of twenty-four hours.

Another terrible and very widespread disease was leprosy. Hospitals and pest-camps were founded for these afflicted persons, who, if in fairly good health, had to go about dressed in a marked manner—a black gown with two white bands sewed upon the breast, and a large hat with a white band upon the head. Whatever they wished to buy, they must point out with a long stick, and their approach must be indicated with a rattle.

“Holy-fire,” or ergotism as it is now understood, was, if anything, worse than leprosy, for it maimed horribly those who did not die, deprived them of a hand or foot. It is a gangrenous disease caused by eating a fungus of rye, in bread, and is very painful. Scurvy was another disease due to malnutrition and improper feeding. It was most marked and diffuse in the fifteenth century, when it sprang out among those who traveled at sea for any length of time, where they could get no fresh vegetables or fruits, but must needs eat salt pork and dry biscuits.

Epidemics of influenza appeared in the early ages, and from those times it has been the custom to say, after sneezing, “God help us,” because those attacked with this disease, often died too quickly to expect aid from human hands. “The Black Death” was a most terrible and destructive plague. It is computed that fully one-fourth of all mankind was swept away by this plague! Besides these awful diseases, there were many famines, brought on about every decade or so, because of the widespread lack of cultivation of the lands, and the universal insecurity of property.

CHAPTER V

THE CLOSE OF MEDIEVALISM

AT the beginning of the Modern Era, continuing of course from the Middle Ages, the influences of superstition and ignorance were not at once obliterated, nor are they even to the present day. Martin Luther himself, the central figure of the greatest political and religious movement of all modern centuries, believed absolutely in the devil incarnate, and in all diseases he regarded the influence of Satan as paramount. The physicians were likewise under this influence. Even Paré believed in the workings of demons and the devil. And if great minds like those of Luther and Paré are found to have been fettered to those old ideas and beliefs, how much more must the lower classes and the ignorant have been?

But the most powerful agents in bringing about a better era were the new philosophical and skeptical currents of thought which arose to subject all medievalism to the tests of proof and doubt. This spread of new thought was due mainly to universal schooling and mental culture. Another influence which soon brought about an improvement in thought and education was commerce, developing ocean travel and through it bringing men of different languages and customs into intimate contact with each other.

Medicine in the beginning of the Modern Era received its mightiest impulse from the same strongly Protestant and progressive spirit which in the department of religion broke the solidarity of the ancient Church. In medicine,

however, this spirit was led not only against the Church but also against Galen, against the Arabians and against the superstition of the priests and monks. Thus was called



Fig. 6—PHARMACY DURING REVIVAL OF LEARNING

into existence a national medicine which through the living spirit of the nations and through their language won fresh momentum. The new forms of disease which had arisen in the last years of the Middle Ages brought a more

reliable differentiation of the species of disease. The etiology and treatment of those new diseases could not be found in the records of the ancients, for the latter had never seen them; so it was a matter of sheer necessity to investigate them and learn all that was possible. The allied sciences of chemistry and botany, supplied with new material from the Old World, also advanced in many positive ways into the sphere of Medicine. Anatomy, already started on its correct basis, and physiology, which is founded upon anatomy, both advanced more rapidly.

The sixteenth century is as important in the development of medicine and its allied branches as was the age of Hippocrates, for during this time his principles and precepts were developed to a most wonderful degree. It was the century of reformation, of struggle and of protest against all medicine which had abandoned the teachings of Hippocrates; it was the outcry against tradition and authority and for correct principles of observation of nature. The levers whereby this reform was accomplished were humanism, the new anatomy, new diseases and the rebellion of Paracelsus and Paré.

Altho there is found an earnest effort to advance, a retrograde impulse of equal strength made itself manifest. Beside the clearest discernment stood darkest superstition; beside poor dupes stood the grandest impostors. At this time are found the superstitious physicians preaching that astrology is necessary for the study and the treatment of disease, while the belief in witches and their trials were approved by a large majority of the medical profession. The advances in mathematics and astronomy under the influence of the Copernican system laid the foundation for the final disbelief in astrology. The physicians of the sixteenth century were very active in philology and in translating and commenting upon the works of the ancients and the influence of these works was immediate. The reform proceeded from no single individual nor even from any one nation. The reaction became universal against Galen and

the Arabians and terminated with their almost complete demolition. The first combustible thrown into the stagnant air of blind faith in authority was in the form of a dispute concerning the proper place for venesection in pleurisy, meaning both pleuritis and pneumonia. Now it seems a trivial thing, but at that time was so important that the medical profession was divided into two camps. The site to be chosen for bleeding was the whole subject of contention.

Pierre Brissot, a Parisian (1478-1522), taught the Hippocratic method of venesection. Many came to his side, but he gained more adversaries. Both Vesalius and Paré followed Brissot.

Paracelsus (Theophrastus von Hohenheim) lived about the same time as Brissot. He was instructed first by his father, who taught him alchemy, astrology and medicine. He studied at the University of Basle and later traveled as an itinerant student and surgeon in the wars. He was the first to deliver lectures on medicine in anything but the Latin language; that is, in German. As a result he had a great many hearers. But Paracelsus was far from modest concerning his own ability and standing. He proclaimed himself the greatest medical genius of Germany and compared himself with Hippocrates, whom he revered. As an outward and popular sign, he burnt the works of Galen and Avicenna in his lecture rooms, thus showing his unbelief in and disdain for these ancient authorities. He believed that experience and observation made the physician, not the knowledge of Latin and Greek and the useless principles of the ancients. Altho not properly educated in his department, he was possessed of ingenious medical instincts and through his extensive travels was better fitted for the work of a reformer than were the literati of the profession, who trod universally the paths of Galen and the Arabians.

His humanity and charity, virtues of the genuine physician, were famous. If he was rough and unpolished, it

was because the times developed such men, and he could be gentle and kind. The influence that Paracelsus exerted was mostly on the Germans, because he wrote and spoke only in that language. Furthermore, his influence was limited to the unlearned rather than the learned, for the very reason that he did not know Latin and Greek, in which languages medicine had always heretofore been taught. Paracelsus was both a surgeon and a physician, at that time a rare circumstance, and he points out with great clearness and comprehension the great value of the alliance of these two departments of the medical science. Altho he was himself no operator, he taught the principles of the treatment for wounds. He held very strongly to the cleanliness of wounds, almost too strongly in direct opposition to the customs of the day, recommended spare diet and regulation of drink. In the treatment of ulcers he was less clear, but he used to good advantage mineral remedies and compression with bandages.

The physiology of Paracelsus recognises as the proper active and life-giving agent in man his 'archeus,' whose home is in the stomach, who separates the material useful for nutrition (the 'essence') from the useless (the 'poison') and becomes thus the 'alchemist of the body.' Moreover, he is the spirit of life, the 'astral body.' The poison is excreted by two routes—all excrements are therefore poisons—and the essence remains in the body. It nourishes and maintains the latter, while each part and each member (since all possess their own special archeus, alchemist or stomach) attracts, extracts and assimilates what is appropriate for it. Digestion is a kind of putrefaction by which, on the one hand the assimilation of the nutritive slime, on the other the formation of the excrement, is rendered possible. Health is recognised by the regular action of this archeus.

A striking similarity with the doctrines of Darwin is found in the view of Paracelsus that the origin of everything is simply the transformation of germs always exist-

ing (and therefore is a metamorphosis), as well as in the fact that he maintained that every object and being originated at the expense of and through the destruction of another, a doctrine in which is seen already developed the war of individual against individual and the struggle for existence so much talked about nowadays.

Upon anatomy in the modern sense of the term—he calls it local anatomy—Paracelsus laid no weight so far as concerns internal disease. He opposes to it a universal anatomy which the physician must know in order to cure and to understand diseases. Under this universal (or general) anatomy he understands the separation into that triad of fundamental bodies—salt, sulphur, mercury—of which the body consists, as well as the knowledge of the nature and power of an object and of its celestial model. In attempting to explain the phenomenon of life he mixed philosophy, alchemy and physiology. He believed that sulphur represented combustible elements in things, salt the soluble and mercury the volatile elements. He thus supported the theories of Valentine, for he too was a skilled alchemist.

The parts of the body stand in reciprocal relation with the stars, and, in fact, the seven great organs—the brain, heart, lungs, gall, kidneys and spleen—correspond to the moon, the sun, Mercury, Mars, Jupiter, Venus and Saturn. Furthermore, he makes seven kinds of pulses as there are seven planets. Epilepsy resembles the earthquake; apoplexy the lightning; flatulence the wind-storm; dropsy, inundations; the chilliness of fever, the quaking at the origin of new worlds. Fever in itself, according to his views, is an effort of the healing power of nature to equalize the disturbances of the body; that is, to cure. Paracelsus divided diseases into material and spiritual, acute and chronic.

The doctrines which he taught with such zeal were in the main the doctrines of Valentine, but enlarged and developed by the new light which he had gained by his own researches and studies. He discovered many new chemical

bodies and introduced many new remedies. To him is largely due the spread of that drug, which perhaps more than any one drug has influenced the fortunes of mankind—namely, laudanum, the use of which is said to have been due to him. He was emphatically not an anatomist, not a physiologist, but a pharmacologist. He paid little heed to the doctrines of Galen and cared little or nothing for anatomy. He was a chemist to the backbone and his pathology was based not on changes of structure and their attendant symptoms but on the relation of diseases to drugs. He insisted that diseases ought to be known by the names of the drugs which cured them—*morbis helleborinus* and the like. In this he was a forerunner of an errant school of the therapeutics in modern times.

He believed that the color and physical properties of drugs should correspond somewhat to the locality and nature of the disease. As in the case of diseases of the eye, one should use *euphrasia*, because the black spot on that flower points the pupil of the eye. Also gold must be used in diseases of the heart because gold, according to cabalistic assumption, harmonizes with the heart. He was cautious in the use of venesection, but performed it when his astrological ideas permitted it.

The reform in surgery and its practice during the sixteenth century was the result not only of the change in the instruments used in warfare, but also of the impulse that had been given to the direct study of human anatomy. Altho the old-fashioned weapons were still employed, firearms and cannon were fast taking their places, and the wounds were of a more complex nature, demanding of the physician and surgeon a more intimate knowledge of the structures which had been wounded. This transformation of surgical after-treatment was the work of a single man, who so changed the prevailing methods of technique that those following in succeeding years began at once the uplifting of surgery to the foremost position which it to-day occupies.



AMBROISE PARÉ OPERATING ON THE BATTLEFIELD.

Ambroise Paré (1510-1590) was the son of a barber and followed in his father's footsteps by being first a barber. When he had become a barber-surgeon at nineteen he went to war as an army surgeon and there spent many years on the battlefields, the best school of surgery. Altho by no means learned, he was most gifted, being an essentially practical physician. His fame became so great that he was appointed as one of the twelve royal surgeons and he was made a member of the great exclusive Collège de St. Côme, whose professors even overlooked the fact that he knew no Latin. Truly a great honor. The chief work of Paré was not the result of any inspiration, but was more or less an accident. Gunshot wounds up to this time had always been considered poisoned and the treatment of such was to destroy the dangerous poisons. This was considered to be best done by cauterizing the wound with boiling oil. After a rather heavy day's fighting, in which many men had been wounded and were lying in the hospital tents awaiting their time for the prescribed treatment (there were no anesthetics used in those days), Paré found that his supply of oil had run short and that he could get no more for some days.

The knowledge of this fact upset and alarmed him a great deal, for he saw nothing but death for the untreated soldiers. These he was compelled merely to dress with clean cloths. Paré retired to bed that night, a tired and anxious man. The next morning he sought out without delay the men expected to die shortly, but what was his amazement and delight to find that they were all in far better condition than their comrades who had been subjected to the routine treatment with boiling oil! They suffered less pain, had fewer general symptoms, hence were more comfortable and the wounds were in better shape, there being less inflammatory reaction in them. Paré at once introduced this new idea into his treatment of wounds and began immediately to obtain much better results. As soon as he was himself positive of the superi-

ority of this new method of treating gunshot wounds he wrote a treatise on the results of his great discovery, thus promoting surgery not only in France but throughout the world.

Another great achievement of Paré was the recommendation and practice of ligation of arteries when divided and bleeding. Altho this had frequently been done by the ancients and the Arabians, it had been dropped and supplanted by the red-hot cautery. Paré discovered it quite independently and deserves more credit because he applied it in the practice of amputation. In regard to amputations he was also a pioneer, for he excised a limb not through gangrenous and diseased tissues but above those areas, through the sound and healthy tissues, thus favoring the chance for primary healing without the formation of pus and infection. It is interesting to note that when large blood-vessels were ligated the surgeons took great care to include the nerves in the ligature, thinking thus to prevent the escape of any vital spirits! Paré was the first surgeon to use to any extent trusses for the reduction of ruptures (or hernias). He introduced many new plastic operations for deformities and invented feeding-bottles for the artificial feeding of infants with cows' milk.

In England two physicians of high rank—Linacre and John Kaye—freed English medicine from the control of the clergy and at the same time laid the foundation for the self-government of the English physicians.

As the new varieties of wounds necessitated a more thorough investigation and knowledge of anatomy, that subject began to be developed extensively. As Baas points out in his complete 'History of Medicine,' serious errors, handed down from antiquity, proved genuine hindrances to a far grander advancement. Such was the Galenic doctrine that the arteries, since they were empty in the cadaver, contained only the vital spirits, and that the veins alone contained blood; that the blood flowed forward in the veins during inspiration and backward in expiration, with-

out returning to the heart, and was entirely consumed in the processes of nutrition.

It was in this sixteenth century that Galen's long hold on anatomy was broken. In this work Vesalius took the lead, and it is due to him primarily that anatomy was completely reformed, thus laying the foundations for physiology and pathological anatomy, both to be built up very soon.

Andreas Vesalius (1514-1564) was the first to declare that Galen's anatomy was based not upon human, but upon animal dissection. He proved his statement positively by many careful dissections and demonstrations upon the human body. He was the first to employ wood-cuts, made after Nature, in the illustration of his anatomical books. At the age of twenty-three years he was made professor of anatomy at Padua. He at once began to teach anatomy in his own new way. Not to unskilled, ignorant barbers would he entrust the task of laying bare before the students the secrets of the human frame; his own hand, and his own hand alone, was cunning enough to track out the pattern of structures which day by day were becoming more and more clear to him.

Following venerated customs, he began his academic labors by 'reading' Galen, as others had done before him, using his dissections to illustrate what Galen had said. But time after time the body on the table said plainly something different from that which Galen had written. He tried to do what others had done before him; he tried to believe Galen rather than his own eyes, but his eyes were too strong for him, and in the end he cast Galen and his writings to the winds and taught only what he himself had seen and what he could make his students see too.

Vesalius' great work is a work of anatomy, not of physiology. Tho to almost every description of structure there are added observations on the use and functions of the structures described, and tho at the end of the work there is a short special chapter on what is now called experi-

mental physiology, the book is in the main a book of anatomy. The physiology is incidental, occasional and indeed halting. Nor is the reason far to seek. Vesalius had a great and difficult task before him. He had to convince the world that the only true way to study the phenomena of the living body was, not to ask what Galen had said, but to see for one's self, with one's eyes, how things really

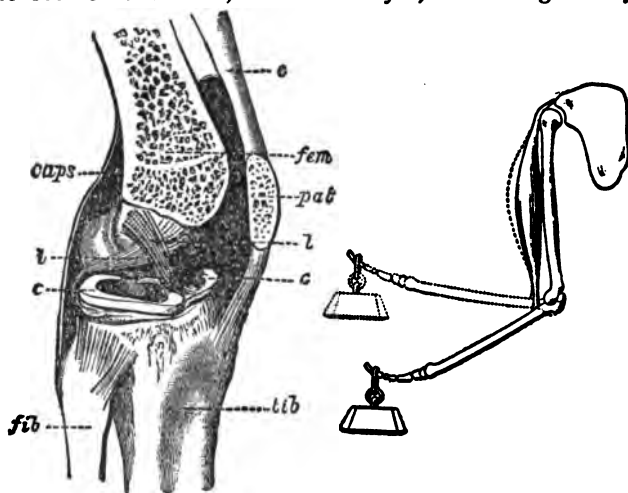


Fig. 7—KNEE-JOINT AND BICEPS MUSCLE; FIRST DESCRIBED BY VESALIUS

Outer half of femur and patella sawn away; fem., femur; tib., tibia; fib., fibula; caps., capsule of joint; l, crucial ligaments; c, semilunar fibro-cartilages; e, tendon of extensor muscle.

Arm, showing shortening of muscle by which a weight is lifted.

were. And not only was a sound and accurate knowledge of the facts of structure a necessary prelude to any sound conclusions concerning function, but also the former was the only safe vantage ground from which to fight against error. When he asserted that such a structure was not as Galen had described it, but different, he could appeal to the direct visible proof laid bare by the scalpel.

Almost everywhere Vesalius placed himself in express opposition to Galen. Thus he denied the existence of the 'os intermaxillare' in adults and the composition of the inferior maxilla of two bones. In like manner he reduced Galen's seven bones of the sternum to three and gave to the sacrum (and coccyx) five or six pieces, instead of the three of Galen. In opposition to the latter, Vesalius also established the existence of marrow in the bones of the hand and refuted his assumption of an imputrescible bone of the heart, as well as his assertion of the strong curvature of the bones of the upper arm and the thigh. He maintained that nerves and muscles stood in no relation of proportionate strength to each other, for that stout nerves were distributed to small muscles and conversely; that the tendons were similar in constitution to the ligaments and not to the muscles, that the latter were in some respects independent.

Vesalius denied the existence of a general muscle of the skin, proved that the intercostal muscles merely separate the ribs from each other, without either expanding or contracting the thorax, and discarded the origin of the vena cava inferior from the liver, all in opposition to Galen. He first described the course of the vena azygos and the subclavian vein, the ductus venosus; gave a description of the structure of the ear, the sphenoid bone of the head, the mediastinum, the peritoneum and omentum and many of the abdominal organs. Of course Vesalius was no more exempt than any other man from individual errors and those of his own and the past age. Thus in his view the veins alone were blood-vessels, while the arteries were still carriers of the vital spirits and simply appendages of the veins.

Even in this, which he ventured to print, the sarcastic note of skepticism made itself heard, but what he really thought he did not dare to put forward. He tells us in a later writing that "he accommodated his statements to the dogmas of Galen," not because he thought that

"These were in all cases consonant with truth but because in such a new, great work he hesitated to lay down his own opinions, and did not dare to swerve a nail's breadth from the doctrines of the Prince of Medicine."

That physiological problems were before his mind, that he had thought over and indeed had tried to solve them by experimental methods, is shown in the brief chapter, 'Some Remarks on the Vivisection of Animals,' which is the last chapter in his great work. In this he relates his experiments on muscle and nerve, showing that which passes along a nerve in order to bring about movement passes by the substance and not by the sheath of the nerves. He affirms that it is through the spinal cord that the brain acts on the trunk and limbs; that an animal can live after its spleen has been removed; that the lungs shrink when the chest is punctured; that the voice is lost when the recurrent laryngeal nerve is cut; that by artificial respiration an animal can be kept alive, tho its chest is laid wholly bare, and that under these circumstances a heart which has almost stopped beating may be revived by the timely use of the bellows.

Vesalius' results were impugned and indeed were corrected by his compeers and his followers, but they were impugned and corrected by the method which he had introduced. Inquirers asserted that in this or that point Galen was right and Vesalius was wrong, but they no longer appealed to the authority of Galen as deciding the question; they appealed now to the actual things as the judge between the two. And even those who were Vesalius' most devoted disciples never made of him a second Galen; they never appealed to him as an authority, for they were content to show on the actual body that what he had said was right.

Under a more special aspect he may be regarded as the founder of physiology as well as of anatomy, inasmuch as physiology is based upon anatomy, and he was the distinct

forerunner of Harvey, for Harvey's great exposition of the circulation of the blood did, as will be seen, for physiology what Vesalius' "Fabrica" did for anatomy; it first rendered true progress possible. And Harvey's great work was the direct outcome of Vesalius' teaching, the direct outcome and yet one reached by successive steps, steps taken by men of the Italian school, of which Vesalius was the founder and father.

Pathological anatomy had its beginning, small as it was, in this century, and it grew naturally as a result of the great anatomical zeal. It began really as a search for curiosities and gross abnormalities. The horror and dread of dissecting and thus defiling the dead were fast being stamped out, especially in the minds of earnest medical students, who had profited by Vesalius' great rebellion against the anatomy of Galen. The human body was searched for stones and concretions, which were found in the kidneys, bladder, lungs, gall-bladder, brain and other places, thus further deciding against Galen, for he insisted that there could be stones only in the kidney and bladder.

Servetus, an anatomist of a few years later, was the first to teach that the septum between the chambers of the heart was not perforated, as had been advocated. In his "Restitutio" occurs this remarkable passage:

"In order, however, that we may understand how the blood is the very life, we must first learn the generation in substance of the vital spirit itself which is composed and nourished out of the inspired air and very subtle blood. The vital spirit has its origin in the left ventricle of the heart, the lungs especially helping toward its perfection; it is a thin spirit, elaborated by the powers of heat, of a yellow (light) color, of a fiery potency so that it is, as it were, a vapor shining out of the blood, containing the substance of water, of air, and of fire. It is generated through the commingling which is effected, in the lungs, of the inspired air, with the elaborated subtle

blood communicated from the right ventricle to the left. That communication does not, however, as is generally believed, take place through the median wall (septum) of the heart, but by a signal artifice the subtle blood is driven by a long passage through the lungs. It is prepared by the lungs, is rendered yellow (light) and passes from the artery-like vein. In the vein-like artery it is mixed with the inspired air, and by the expiration is cleansed from its fumes. And so at length it is drawn in, a complete mixture, by the left ventricle through the diastole, stuff fit to become the vital spirit.

"That the communication and preparation does take place in this way through the lungs is shown by the manifold conjunction and communication of the artery-like vein with the vein-like artery. This view is confirmed by the conspicuous size of the artery-like vein which would not have been made so large and so stout, and would not discharge from the heart itself such a power of very pure blood into the lungs for the mere purpose of nourishing these organs. Nor would the heart serve the lungs in this manner, especially since at an earlier date in the embryo on account of the little membranes of the heart, the lungs themselves are up to the hour of birth nourished from other sources, as Galen teaches."

These words show beyond all possible doubt that Servetus rejected wholly and unreservedly the hypothetical passage of the blood through the septum; he went far beyond the merely hinted skepticism of Vesalius. They further show that he had grasped the true features of the pulmonary circulation, the passage of the blood from the right side through the lungs to the left side. He must have attained these results by his own unaided inquiry and thought; and had he given to science the labors which he gave to theology, he might have deserved the title of one of the great physiologists of the time.

Servetus' only obscure point in his theory of the lesser circulation, as the pulmonary circulation is called, is that the blood returning from the lungs to the heart, through the pulmonary veins, contained *pneuma* (air) and blood. A few years later, however, this idea was dispelled by Colombo, who demonstrated, by experiment, that the pulmonary veins contained blood only. Cesalpino, a pupil of Colombo, came nearest to Harvey in describing the lesser circulation perfectly, saying that the blood anastomosed from arteries to veins in the lungs; that the blood was cooled in the lungs, and that no air was in the blood. Yet he admitted the existence of pores in the wall of the heart. He also held some correct views concerning the greater circulation.

For the performance of all dissections in the universities (they were still prohibited by the Church) papal indulgences were necessary, and these, of course, cost money. Tübingen received such an indulgence as early as 1482, while in Strassburg, in spite of papal prohibition, permission to dissect an executed criminal was granted by the magistrates in 1517. Before and after each special dissection (which was, however, a relatively infrequent occurrence) religious ceremonies in many places were considered necessary. In order that those who came into contact with it might not become 'disreputable,' the corpse was first made 'reputable,' the professor beginning the proceedings by reading a decree to that effect from the lord of the land, and then, by order of the Senate or the medical faculty, stamping upon its breast the seal of the university.

The body was then carried (upon the cover of the box in which it had been brought in) by volunteers for this service into the anatomical hall, and the cover, upon which it rested during these ceremonies, was then taken back to the executioner, who had meanwhile remained at some distance with his vehicle. Afterward entertainments, graced with music by the guilds of city fifers, trumpeters, trombone players, etc., or by "itinerant actors," were given.

Gradually, however, this folly waned, and in the second half of the century, public anatomical theaters were established. Such a theater was built by Fabricius ab Aquapendente in Padua (the most popular and famous medical institution of the sixteenth century), at his own expense, in 1549. The price of a skeleton in that day was very high. Thus Heidelberg in 1569 paid \$72 for a single skeleton, an immense sum in ancient values.

The higher physicians, usually of the laity and not clergy, received their education in the universities. The Italian were the best, altho France and Germany had excellent schools. The students, especially in upper Italy, were so strong and large a community in themselves, that they controlled the university, both its curriculum and the appointment of its professors. The poorer students were known as "Traveling Students." They traveled from first one Latin school to another, gradually becoming more and more fitted, and thus advanced themselves to the best university. They traveled in bands or groups, and during their pilgrimages, the worst sort of atrocities and crimes were committed. They supported life in many ways, by singing, begging and stealing. The "traveling" began in early youth, and for many students never came to an end. Some few of them became great men, but most of them fell into dissolute and vicious lives.

The physicians of this century were quite as roving as the students and professors. Surgery was largely neglected, as unbecoming a gentleman, so that it was relegated to a lower class of practitioners. The self-satisfied literati considered it an important part of their business to consult the stars for proper time to bleed and purge a patient. In general, the physicians of the so-called "long-ropes" enjoyed considerable respect, but they never treated the masses, not only because they did not want to, but also because the poor people were not advanced enough to go to them.

CHAPTER VI

THE CENTURY OF SCHOOLS

THE seventeenth was the "Century of Schools," the outgrowth of the adoption into medical science of accessory natural sciences such as physics and chemistry. Germany, involved in the great thirty years' religious war, was not able to advance in the sciences as she had done in the preceding century, so other countries took the lead, especially England and Italy. The sixteenth century had been idealistic, but in the seventeenth, modern realism in all departments of thought was developed, and in the adoption of the natural sciences, often to an extreme degree, medicine gave the first instance of the modern "exact" method. Hence this century is called the greatest in the development of medicine. As the accessory sciences developed more and more, they acquired an influence over and control of medicine proper to an alarming extent. Physicists and chemists took control of medicine, not only in trying to theorize and explain life's phenomena, but even to the extent of dictating methods of treatment, the real purpose of medicine being lost sight of—that is, the cure of disease and alleviation of human suffering.

One of the greatest inventions ever made, and one of especial importance in the advance of the medical sciences, was that of the microscope by Jansen in 1620. Other inventions, such as the thermometer, besides many discoveries of natural laws in physics and astronomy, had no little influence on the advancement of medicine. The

natural sciences became separated in this century from philosophy and religion, and became founded upon the correct basis of observation and experimentation. Zoölogy and botany, after the discovery of the microscope, made rapid advances, also having their influences on anatomy, both normal and pathological. The first classification of plants led to the effort to study diseases in a similar manner.

The influences of preceding centuries was still felt, but it had been so broken, that only in certain quarters could it wreak harm. Altho Galen and the Arabians, and even Hippocrates, made themselves felt here and there, Paracelsus possessed by far the largest number of disciples. The doctrines of this mystic and pietist were gathered by Van Helmont into a system based upon chemical principles. The latter was a true son of his century, a mystic and at the same time, a realist. He studied mathematics, astronomy, philosophy, medicine and chemistry, vacillating from one to the other. The system which he founded was not an enduring one, and he had only a few followers. In his doctrine of the elements, he differs from the ancients and from Paracelsus, in regarding air and water as elements, and held that from water, everything on earth takes its origin. Man has a soul, commanding a spirit called the "Archeus," which exists also in lower animals. Besides these, there is also "gas," which arises from the action of the Archeus on the water. The active principle of the Archeus, both in health and disease, is a ferment. The "ferment" is the chief agent in digestion, adheres to the acid of the stomach, and obeys the commands of the Archeus.

Deeply impressed with this idea of the action of ferments, Van Helmont makes it the basis of his system of physiology. Nearly all the writers before him had caught hold of the phenomena of the fermenting wine-vat, as being, though mysterious in themselves, illustrative of the still more mysterious phenomena of the living body; and

the old idea of the physiological spirits of the body, natural, vital and animal, was connected in its origin with this same formation of alcohol, of spirits of wine by fermentation.

His exposition of physiology is based on the theory of fermentations. The ordinary vinous fermentation gives him his initial idea; following this up, he regards all the changes in the body (not digestion only, but also others, including nutrition, impregnation and even movements) as due to the action of ferments.

He assumes the current teaching of the day to be (1) that the food absorbed from the stomach and intestine is in the liver endued with natural spirits, (2) that in the heart the natural spirits are converted into vital spirits, and (3) that in the brain the vital spirits are converted into animal spirits. He claims there are six different grades of digestion, corresponding to the days of creation.

In accordance with these cosmogenetic and physiological views, Helmont in his general pathology considers disease something active, not simply an impairment or loss of health. The general cause of disease is the fall of man. As regards special pathology, disease depends upon a perverted action of the Archeus, upon morbid ideas, or upon errors of the Archeus, as the result of which it sends the ferment of the stomach to improper places. These morbid ideas of the Archeus arise, however, from its anxiety, dread, hate, terror, anger, or passion. Fever is an expression of the sensibility of the Archeus injured by the cause of the fever. The period of chill is the expression of its passion or terror; the stadium of heat, that of its fury. On the other hand, inflammation originates in a "spina" (irritation), which springs from excitation of the Archeus, or from external causes. Among the occasional causes of diseases Van Helmont ranks demons, witches, ghosts, necromancers, and similar weird forms.

Van Helmont's special etiology gives as the cause of

dropsy, hindrance to the excretion of urine by the enraged Archeus. In inflammation of the chest, where, he says, the blood coagulates outside of the vessels, the Archeus sends the acid secretion of the stomach into the lungs; in gout, into the joints, etc. In catarrh the mucus is formed from the remnants of the food sticking to the palate; vesical calculi originate in a deposit of the urinary salts. "Putrefaction" in the closed lumen of the vessels he does not recognise as the cause of disease in fevers. Altho Van Helmont made local diseases so very prominent in his system, and therefore desired to improve the condition of pathological anatomy, still, like Paracelsus, he placed no value upon normal anatomy. Surgery he claimed to be inseparable from medicine.

Altho in therapeutics Van Helmont laid great weight on universal medicine, conjurations, charms and prayer, and in his pious style claimed God's mercy as the basis of the efficacy of medicines, yet he did not despise earthly remedies, whose active principles are contrasted with the chemical constituents. He gives opium (to the stimulant effect of which, for the first time, he called attention), mercury, antimony and wine in fevers (alcoholic treatment of fevers), and makes frequent use of Arcana. The latter, in his view, are to be considered specifically active against the wrathful, or in any way excited Archeus, against whose discontent and ill-humor and morbid ideas in general, all therapeutics were to be directed; while the remedies first mentioned, especially those of metallic origin, act in a similar way, only not specifically.

In general he lays stress upon simple chemical remedies, and abhors bleeding because of its tendency to debilitate, a tendency to which he first called attention. In the colossal abuse of bleeding which prevailed at this time, his caution on this subject merits every commendation. In the calendars, bleeding, according to the rules of astrology, was preached as a general prophylactic until the opening of the present century.

The medical studies, in which Van Helmont first found something solid to rest upon, were not the vague Galenic teachings which were all that had been offered to Paracelsus, but teachings based on the exact anatomical knowledge provided by Vesalius and his school, and on all which that knowledge carried with it. By gas, he meant, and by the introduction of the new term indicates his appreciation of the discovery of, what is now called carbonic acid gas, or carbon dioxide; and the development of a great deal of chemistry, and especially of the chemistry of living beings, has turned on the nature and properties of gases.

It was in relation to this gas that Van Helmont parts company with Paracelsus. He argues that Paracelsus was wholly wrong in maintaining that sulphur, mercury and salt were the three elements. There are, he contends, two elements only, air—that is to say, the natural atmosphere—and water. He spends much time in proving that air and water can never be changed, the one into the other; that they are distinct and never convertible; that the vapor of water is something wholly different from real air. On the other hand, by what he called water, he meant everything which is not air; he insists that all things, plants and animals, can be reduced to water, that they are in fact water endued with certain properties.

The Chemical System, founded by Sylvius (1614-1672), was based upon the elements of chemistry, the new knowledge of the circulation and the improved anatomy. It absolutely neglected the vital forces of life. It was a system of "humors." Altho Van Helmont paid little heed to that part of physiology which is derived by deductions from anatomy, by experiments on animals or by the application of mechanical principles, Sylvius was well versed in all these things, and wrote well on the circulation of the blood and on the mechanics of respiration.

The humoral physiology of Sylvius, instead of the four cardinal fluids, adopts the "triumvirate" of the saliva, the

pancreatic fluid and the bile. Instead of the varieties of the pnuma, it accepts the collective idea of the "vital spirits," in contradistinction to the system of Van Helmont, and from this time forward played one of the most prominent parts, and occasioned the greatest confusion, in the theoretic views of medicine. The forces were compelled to give place to the chemical process of fermentation and effervescence, the qualities, to acid and alkali (originating in the acid or alkaline salt). Saliva and pancreatic fluid are acid. The bile is alkaline; the first effects stomach-digestion, while the two latter accomplish the digestion of the chyme into chyle and feces. In this process, an effervescence occurs and produces a kind of gas, which, in the form of volatile spirit, with a delicate oil and salt neutralized by a weak acid, enters into the composition of the chyme. Such a spirit of fermentation is also transmitted from the spleen to the blood and perfects the latter. Hence the importance of the spleen (with which the glands are connected in importance and action) becomes perfectly clear.

The blood is the headquarters for the development of the processes of healthy and of morbid life. Normally, it contains the bile already preformed. This is separated in the gall-bladder, but again partially mixed in the liver with the blood, whose fluidity it serves to maintain. The blood and bile then proceed to the right side of the heart, where both (together with the chyle) bring about a vital fermentation by means of the innate heat of the latter organ. In the lungs the blood of the right heart is again cooled, and passes to the left side of the heart, which, on its part, is dilated by a new "effervescence" of the blood.

The contraction of this half of the heart is now excited by means of the vital spirits, and the blood is driven into the greater circulation. These vital spirits, comparable in their nature to alcohol, are distilled in the brain (still regarded as a glandular organ), and are carried by the nerves (which were supposed to be hollow) to the whole

body, in order to facilitate sensation. The vital spirits which reach the glands, by means of an acid developed from the blood, undergo here their metamorphosis into lymph. Under the form of lymph they return once more to the blood, passing from the glands into the brain, thus forming a circulation distinct from that of the blood. The milk, however, which is related to lymph, originates from the blood, which, through the influence of a mild acid prepared in the mammary gland, changes its color in that organ, just as vegetable colors are changed by the action of acids.

According to the general pathology of Sylvius, health consists in the undisturbed performance in the body of the process of fermentation, without the appearance of the acid or alkaline salt. If, however, one of the two latter salts becomes prominent, it gives rise to an acidity and furnishes the cause of diseases. The individual diseases are divided into two groups: those depending upon an acid acidity, and those originating in an alkaline acidity. The two varieties of acidity, however, are subject to numerous modifications, and thus arise subordinate classes of the above groups of diseases. The bile is an example of the principal humors; if it is alkaline, it occasions ardent and continued fever; if acid, it is the cause of engorgements.

In regard to the semeiology, diagnostics and therapeutic principles of Sylvius, the following passage furnishes some clue: "As often as the whole blood appears black, it indicates that acidity predominates; if the blood is redder, it shows that the bile in it is superabundant. In the first case, that acid in the body and in the blood must be diminished; in the second, the bile must be lessened and its power broken. If the blood, which normally is free from odor and of a sweetish taste(especially the serum), tastes salty, the alkali in the body is too pure, and when brought into contact with the acid spiritus, engenders a humor of a saline taste and prejudicial to the body; for such a taste,

tho milder, may pass into the urine, but not into the serum or its products, the lymph, the pancreatic juice and the saliva. This saline taste indicates a reduction and correction of the alkali." Fever is diagnosticated by the pulse, not by the heat of the body.

Accordingly, therapeutics has two extremely simple duties: to get rid of the acid or the alkali. The first is accomplished by the administration of alkalis, the latter, by the prescription of acids. The "effervescence of the bile" and the diseases flowing therefrom are removed by cathartics. Sylvius recommended diaphoretics, absorbents and emetics, but reprehended bleeding. Opium is of service against both acid and alkali, since it tempers equally both acridity and effervescence. The general objects of therapeutics (never, alas, to be accomplished) are "to maintain the strength, to remove diseases, to mitigate symptoms and to remove their causes." The stereotyped theory, and especially the stereotyped therapeutics of Sylvius gained for him a large following; but they also procured him numerous opponents, especially in later times, when his therapeutics were reproached with having during their prevalence cost, on the whole, as many human lives as the Thirty Years' War. This, under any circumstances, is an exaggerated estimate, for nature, from the most remote ages down to the present day, has preserved the sick, at least in the majority of cases, from the worst consequences of the healing art of infatuated theorists and corrupt or incapable practitioners. But Sylvius must be given credit for having brought the chemical investigation of physiological problems into line with the mechanical and physical investigation of them.

In opposition to the Chemical School, Borelli (1608-1679) formed the Mechanical or Physical School. He sought to explain most, if not all, the phenomena of the living body as mere problems of the new mathematical, mechanical and physical science. For instance, he taught that digestion is a purely mechanical process. Concerning

gastric digestion itself, Borelli, with his mind directed chiefly to mechanical effects, had pointed out the great grinding, crushing force which was provided for by the muscular coats of the stomach. He calls attention to the fact "that in birds, with few exceptions, the crushing, erosion and trituration of food is effected by the muscular stomach itself, compressing one part of its horny lining against another. Thus, with the help of small hard and sharp pebbles contained in it, which serve instead of teeth, the stomach, by pounding the food swallowed and rubbing its inner surfaces on it this way and that, like millstones, crushed the parts of the food until they are converted into a very fine powder."

He appears to think that in most birds the digestive action is wholly mechanical, and indeed he maintained that the pebbles in the stomach might be not only mere mechanical aids, but when crushed might serve for nutriment. He admits, however, in the case of some stomachs, there is a corrosive juice. In this point, as in others, the followers of Borelli went beyond their master, and the physical school after him were prepared to deny action in all cases, and to maintain the digestion was in reality a mere trituration of the food by the muscular mill of the stomach into the creamy mass known as chyle.

In pathology Borelli was an opponent of the Chemical School, on the ground that it was demonstrable neither by common experience nor by experiment, and he denies as well any evidence that fever originates in excessive action of the heart-muscle, due to irritation of the latter by an acrid nervous-fluid. There is no such thing as corruption of the blood, and, even if there were, a stoppage of the organs of secretion is rather to be assumed. In his therapeutics Borelli considers purgation and bleeding ineffective in removing the acidity of the nervous fluid, but he expects that strengthening the organs by means of cinchona and favoring the invisible perspiration will be

the more effectual in fever. He alone, too, remains true to the mechanical theory in therapeutics.

There was one man, however, in this century of unscientific systems or schools, who steered clear of the influences of his day. He was Thomas Sydenham (1624-1689), an Englishman. His model was Hippocrates, upon whom he seems to have formed himself almost exclusively, and whose principles, with some modifications resulting from the condition of knowledge in his day—on the whole, only a few—he made his own. In pathology he was, like Hippocrates, a humorist without being a theorist, and he defended himself against those who laid this to his reproach in almost the same words used by Hippocrates. Like the latter, too (Sydenham was called the “English Hippocrates”), he knew only one standard—observation and experience—tho he was somewhat skeptical as to the certainty of their results, and, like him, he recognised nature, or the healing power of nature, as the sole, ultimate, undefined and undefinable, but (fortunately for physicians) existing and powerful assistant.

In accordance with his disposition to practical objects, Sydenham laid little weight upon anatomy and physiology, a feeling which he shared with almost all great practitioners. Yet he recognised their value when not employed in the production of hypotheses based upon pure theory. The latter he rejected, tho he admitted hypotheses borrowed from practice for the sake of elucidating disease, and especially for the determination of curative indications, or of a definite therapeutics (hypotheses based upon practice).

While Medicine was thus struggling through its systems and schools, Surgery worked slowly and surely into a scientific branch free from speculation and theories. The tourniquet was invented by Morel, and the first transfusion of blood from one person to another was performed by Denis. Obstetrics advanced even more than surgery, and began finally to pass out of the hands of women into

the care of men, and these simple surgeons, not physicians, contributed not a little to its improvement. Scientifically it was greatly benefited by anatomy and physiology, but practically it did not make such marked progress at first. The invention of obstetric forceps was at first of no benefit to practical obstetrics, since it was kept secret by the Chamberlen family, who invented the instrument. Seventy-five years after the occurrence of this invention, De la Motte was driven to utter the following sentence, which, even if it be just, is not particularly merciful: "He who keeps secret so beneficent an instrument as the harmless obstetric forceps, deserves to have a worm devour his vitals for all eternity, for all human science, up to the present time, has not been able to find such an instrument!"

The circulation of the blood was first correctly and distinctly set forth by William Harvey (1578-1667). He was an Englishman, who studied first at Cambridge and then went to Padua, where he worked in the study of medicine for four years. It must be remembered that Harvey had not the exact sciences of physics or of chemistry on which to base his experiments. Harvey's must be ranked the foremost master-mind, for altho Vesalius, Servetus, and Fabricius all opened new fields in the physiology of the heart and circulation, it remained for Harvey to demonstrate the great truths which his predecessors had failed to grasp. Refuting the erroneous ideas of the ancients, and with an eye upon the teachings of Aristotle, Galen, Colombo and others—the work of Servetus was unknown to him, while Aristotle and Galen were cautiously opposed—but on all new points proceeding only upon purely experimental methods, Harvey set forth the doctrine of the circulation as it is held to-day. He first presented the ancient beliefs on the subject in his wonderful paper: "As we are about to discuss the motion, action and use of the heart and arteries," he says, "it is imperative to state what has been thought of these things

by others in their writings, and what has been held by the vulgar and by tradition, in order that what is true may be confirmed, and what is false set right by dissection, multiplied experience and accurate observation.

"Almost all anatomists, physicians and philosophers up to the present time have supposed, with Galen, that the object of the pulse was the same as that of respiration, and only differed in one particular, this being conceived to depend on the animal, the respiration on the vital faculty; the two, in all other respects, whether with reference to purpose or to motion, comporting themselves alike. Whence it is affirmed, as by Hieronymus Fabricus of Aquapendente, in his book on 'Respiration,' which has lately appeared, that as the pulsation of the heart and arteries does not suffice for the ventilation and refrigeration of the blood, therefore were the lungs fashioned to surround the heart. From this it appears that whatever has hitherto been said upon the systole and diastole, or on the motion of the heart and arteries, has been said with especial reference to the lungs.

"But as the structure and movements of the heart differ from those of the lungs, and the motions of the arteries from those of the chest, so it seems likely that other ends and offices will thence arise, and that the pulsations and uses of the heart, likewise of the arteries, will differ in many respects from the heavings and uses of the chest and lungs. For did the arterial pulse and the respiration serve the same ends; did the arteries in their diastole take air into their cavities, as is commonly stated, and in their systole emit fuliginous vapors by the same pores of the flesh and skin; and further, did they, in the time intermediate between the diastole and the systole, contain air, and at all times either air or spirits, or fuliginous vapors, what should then be said to Galen, who wrote a book on purpose to show that by nature the arteries contained blood, and nothing but blood, and consequently neither

spirits nor air, as may readily be gathered from the experiments and reasonings contained in the same book?

"Now, if the arteries are filled in the diastole with air then taken into them (a larger quantity of air penetrating when the pulse is large and full), it must come to pass that if you plunge into a bath of water or of oil when the pulse is strong and full, it ought forthwith to become either smaller or much slower, since the circumambient bath will render it either difficult or impossible for the air to penetrate. In like manner, as all the arteries, those that are deep-seated as well as those that are superficial, are dilated at the same instant and with the same rapidity, how is it possible that air should penetrate to the deeper parts as freely and quickly through the skin, flesh and other structures, as through the cuticle alone? And how should the arteries of the fetus draw air into their cavities through the abdomen of the mother and the body of the womb?

"And how should seals, whales, dolphins, and other cetaceans, and fishes of every description, living in the depths of the sea, take in and emit air by the diastole and systole of their arteries through the infinite mass of water? For to say that they absorb the air that is present in the water, and emit their fumes into this medium, were to utter something like a figment. And if the arteries in their systole expel fuliginous vapors from their cavities through the pores of the flesh and skin, why not the spirits, which are said to be contained in those vessels, at the same time, since spirits are much more subtile than fuliginous vapors or smoke?

"And if the arteries take in and cast out air in the systole and diastole, like the lungs in the process of respiration, why do they not do the same thing when a wound is made in one of them, as in the operation of arteriotomy? When the windpipe is divided, it is sufficiently obvious that the air enters and returns through the wound by two opposite movements; but when an

artery is divided, it is equally manifest that blood escapes in one continuous stream, and that no air either enters or issues. If the pulsations of the arteries fan and refrigerate the several parts of the body, as the lungs do the heart, how comes it, as is commonly said, that the arteries carry the vital blood into the different parts, abundantly charged with vital spirits, which cherish the heat of these parts, sustain them when asleep, and recruit them when exhausted?

“How should it happen that, if you tie the arteries, immediately the parts not only become torpid and frigid, and look pale, but at length cease even to be nourished? This, according to Galen, is because they are deprived of the heat which flowed through all parts from the heart, as its source; whence it would appear that the arteries rather carry warmth to the parts than serve for any fanning or refrigeration. Besides, how can their diastole draw spirits from the heart to warm the body and its parts, and means of cooling them from without? Still further, altho some affirm that the lungs, arteries and heart have all the same offices, they yet maintain that the heart is the workshop of the spirits, and that the arteries contain and transmit them; denying, however, in opposition to the opinion of Columbus, that the lungs can either make or contain spirits. They then assert, with Galen, against Erasistratus, that it is the blood, not spirits, which is contained in the arteries.

“Nor let any one imagine that the uses of the pulse and the respiration are the same, because, under the influences of the same causes, such as running, anger, the warm bath, or any other heating thing, as Galen says, they become more frequent and forcible together. For not only is experience in opposition to this idea, tho Galen endeavors to explain it away, when we see that with excessive repletion the pulse beats more forcibly, while the respiration is diminished in amount; but in young persons the pulse is quick, while respiration is slow. So it is also

in alarm and amid care, and under anxiety of mind; sometimes, too, in fevers, the pulse is rapid, but the respiration is slower than usual.

"These and other objections of the same kind may be urged against the opinions mentioned. Nor are the views that are entertained of the offices and pulse of the heart, perhaps, less bound up with great and most inextricable difficulties. The heart, it is vulgarly said, is the fountain and workshop of the vital spirits, the center from which life is dispensed to the several parts of the body. Yet it is denied that the right ventricle makes spirits, which is rather held to supply nourishment to the lungs. For these reasons it is maintained that fishes are without any right ventricle (and indeed every animal wants a right ventricle which is unfurnished with lungs), and that the right ventricle is present solely for the sake of the lungs.

"Moreover, when they appoint the pulmonary artery, a vessel of great size, with the coverings of an artery, to none but a kind of private and single purpose (that, namely, of nourishing the lungs), why should the pulmonary vein, which is scarcely so large, which has the coats of a vein, and is soft and lax, be presumed to be made for many—three or four different—uses? For they will have it that air passes through this vessel from the lungs into the left ventricle; that fuliginous vapors escape by it from the heart into the lungs; and that a portion of the spirituous blood is distributed to the lungs for their refreshment.

"If they will have it that fumes and air—fumes flowing from, air proceeding toward, the heart—are transmitted by the same conduit, I reply, that nature is not wont to construct but one vessel, to contrive but one way for such contrary motions and purposes, nor is anything of the kind seen elsewhere.

"Since, therefore, from the foregoing considerations and many others, to the same effect, it is plain that what has heretofore been said concerning the motion and function

of the heart and arteries must appear obscure, inconsistent, or even impossible to him who carefully considers the subject, it will be proper to look more narrowly into the

Lg, lung.

A¹, arteries to the upper part of the body.

PV, pulmonary vein.

LA, left auricle.

Ao, aorta.

LV, left ventricle.

A², arteries to the lower part of the body.

HA, hepatic artery, which supplies the liver with part of its blood.

Ly, lymphatics.

V¹, veins of the upper part of the body.

VCS, superior vena cava.

Th.D, thoracic duct.

RA, right auricle.

PA, pulmonary artery.

VCI, inferior vena cava.

RV, right ventricle.

Lct, lacteals.

Al, alimentary canal.

Lr, liver.

HV, hepatic vein.

VP, portal vein.

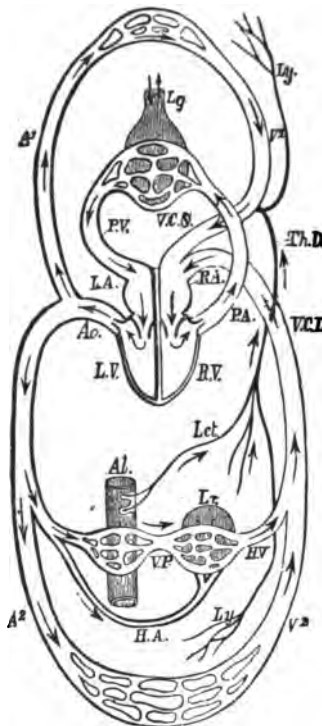


Fig. 8—COURSE OF CIRCULATION OF BLOOD VIEWED FROM BEHIND

The arrows indicate the course of the blood, lymph, and chyle. The vessels which contain arterial blood have dark contours, while those which carry venous blood have light contours.

matter to contemplate the motion of the heart and arteries, not only in man, but in all animals that have hearts; and

also, by frequent appeals to vivisection, and much ocular inspection, to investigate and discern the truth."

Harvey divided the circulation into three sections: the lesser, the greater and that of the heart itself. In his prolonged investigations he made use of both warm and cold blooded animals, but differed from our "exact" investigators of the present day in not describing minutely each individual experiment, but contenting himself with adducing his results and leaving to deduction its just place. He computed the mass of the blood, and thus proved that there must be a circulation, for all the blood could not be employed in nutrition, nor could it all be newly supplied by the absorption of nutriment. Of "spiritus" he said that he had never found anything of the kind in his dissections. He still lacked, however, the intermediate bond of the capillary zone. In place of this he assumed larger porosities of the flesh and vessels, tho he also employed the term "capillaries." He still regards the heart as the place for the improvement of the blood and the renewal of its strength, and calls it "the sun of the microcosm, the beginning of life, the household-god of the body, the author of everything, the foundation of life."

He goes on to describe his experiments on animals and to prove his assertions. "In the first place, then, when the chest of a living animal is laid open and the capsule that immediately surrounds the heart is slit up or removed, the organ is seen now to move, now to be at rest; there is a time when it moves, and a time when it is motionless. These things are more obvious in the colder animals, such as toads, frogs, serpents, small fishes, crabs, shrimps, snails and shell-fish. They also become more distinct in warm-blooded animals, such as the dog and hog, if they be attentively noted when the heart begins to flag, to move more slowly, and, as it were, to die; the movements then become slower and rarer, the pauses longer, by which it is made much more easy to perceive and unravel what the motions really are, and how they are performed. In

the pause, as in death, the heart is soft, flaccid, exhausted, lying, as it were, at rest.

"In the motion, and interval in which this is accomplished, three principal circumstances are to be noted: 1. That the heart is erected, and rises upward to a point, so that at this time it strikes against the breast and the pulse is felt externally. 2. That it is everywhere contracted, but more especially toward the sides, so that it looks narrower, relatively longer, more drawn together. The heart of an eel, taken out of the body of the animal and placed upon the table or the hand, shows these particulars; but the same things are manifest in the hearts of all small fishes and of those colder animals where the organ is more conical or elongated. 3. The heart being grasped in the hand, is felt to become harder during its action. Now, this hardness proceeds from tensions, precisely as when the forearm is grasped, its tendons are perceived to become tense and resilient when the fingers are moved. 4. It may further be observed in fishes and the colder-blooded animals, such as frogs, serpents, etc., that the heart, when it moves, becomes of a paler color, when quiescent of a deeper blood-red color.

"From these particulars it appears evident to me that the motion of the heart consists in a certain universal tension—both contraction in the line of its fibers and constriction in every sense. It becomes erect, hard, and of diminished size during its action; the motion is plainly of the same nature as that of the muscles when they contract in the line of their sinews and fibers; for the muscles, when in action, acquire vigor and tenseness, and from soft become hard, prominent, and thickened; and in the same manner the heart.

"We are therefore authorized to conclude that the heart, at the moment of its action, is at once constricted on all sides, rendered thicker in its parietes and smaller in its ventricles, and so made apt to project or expel its charge of blood. This, indeed, is made sufficiently manifest by

the preceding fourth observation, in which we have seen that the heart, by squeezing out the blood that it contains, becomes paler, and then when it sinks into repose and the ventricle is filled anew with blood, that the deeper crimson color returns. But no one need remain in doubt of the fact, for if the ventricle be pierced the blood will be seen to be forcibly projected outward upon each motion or pulsation when the heart is tense.

"These things, therefore, happen together or at the same instant: the tension of the heart, the pulse of its apex, which is felt externally by its striking against the chest, the thickening of its parietes, and the forcible expulsion of the blood it contains by the constriction of its ventricles.

"And now I may be allowed to give in brief my view of the circulation of the blood, and to propose it for general adoption. Since all things, both argument and ocular demonstration, show that the blood passes through the lungs and heart by the force of the ventricles, and is sent for distribution to all parts of the body, where it makes its way into the veins and porosities of the flesh, and then flows by the veins from the circumference on every side to the center, from the lesser to the greater veins, and is by them finally discharged into the vena cava and right auricle of the heart, and this in such a quantity or in such a flux and reflux thither by the arteries, hither by the veins, as cannot possibly be supplied by the ingesta, and is much greater than can be required for mere purposes of nutrition, it is absolutely necessary to conclude that the blood in the animal body is impelled in a circle, and is in a state of ceaseless motion; that this is the act or function which the heart performs by means of its pulse; and that it is the sole and only end of the motion and contraction of the heart.

"But the following matter seems worthy of consideration, the reason, namely, why veins when ligatured swell on the far side and not on the near side of the ligature.

This is a fact well known by experience to those who let blood; for they place the ligature on the near side of the place of incision, not on the far side, because the veins swell on the far side, not on the near side of the ligature. But exactly the contrary ought to happen if the movement of the blood and the spirits took place in the direction from the viscera to all parts of the body. When a channel is interrupted, the flow beyond the interruption ceases; the swelling of the veins therefore ought to be on the near side of the ligature."

Harvey erred in subordinate points—*e.g.*, in respect to the quantity of blood driven into the arteries at each systole of the heart, which he assumed to be half an ounce—but even if his anatomical description of the structure of the heart was insufficient and, indeed, imperfect, he was certainly the first who introduced the heart into its right place in the circulation in accordance with its mechanical significance and action—an advance which cannot be disputed or denied him. The main facts of his exposition remained quite indisputable, altho in his own day they were heavily assailed, and these accessory matters were eagerly utilized as a means of attack. The previous doctrine of the importance of the liver, and of the "spirits" in the heart, was first overthrown by him, and with it fell the four immemorial fundamental humors and qualities.

That so important a discovery, which cleared up the ancient and time-honored obscurities and overturned the whole physiological and philosophical foundations of the medicine of the past, by certain results gained through the inductive method, necessarily created among medical men both opponents and partizans in great number, is self-evident. It is a fashion to speak of Harvey as 'the immortal discoverer of the circulation'; but the real character of his work is put in a truer light when it is said he was the first to demonstrate the circulation of the blood.

His demonstration was the death-blow to the doctrine

of the 'spirits.' The names, it is true, survived for long afterward, but the names were henceforward devoid of any really essential meaning. For the view of the natural and vital spirits was based on the supposed double supply of blood to all the tissues of the body, the supply by the veins carrying natural spirits and the supply by the arteries carrying vital spirits. The essential feature of Harvey's new view was that the blood through the body, passing from arteries to veins in the tissues, and from veins to arteries through the lungs and heart, suffering changes in the substance and pores of the tissues, changes in the substances and pores of the lungs.

The new theory of the circulation made for the first time possible true conceptions of the nutrition of the body, it cleared the way for the chemical appreciation of the uses of blood, it afforded a basis which had not existed before for an understanding of how the life of any part, its continued existence and its power to do what it has to do in the body, is carried on by the help of the blood. And in this, perhaps, more than its being a true explanation of the special problem of the heart and the blood-vessels, lies its vast importance.

The anatomists of the sixteenth century, and of the early part of the seventeenth century, were content, like their forefathers, to carry on their studies with the naked eye, unassisted by any optical instruments. Hence their statements as to the finer structure of the various organs and parts of the body were necessarily vague and incomplete. They could tease certain parts more or less completely into strands of greater or less thickness, and hence could speak of fibers and of fibrous structure. They recognised skins and membranes of various thickness. They could distinguish what is now called fatty or adipose tissue by means of its gross features. And they could follow out the blood-vessels and later on the lymphatic vessels until these were lost to view as minute channels.

Beyond this, they were content to speak of that part

of the substance of an organ which could not be split into fibers, and into which the minute vessels seemed to disappear, as 'parenchyma,' using the word introduced in ancient times by Erasistratus, but no longer attaching to the word the original meaning of something poured out from the veins. By parenchyma they simply meant the parts which were not distinctly made up of fibers and which in most cases at least were porous. Thus Harvey speaks of the blood which flows along the pulmonary artery as being discharged into the porous parenchyma of the lungs and gathered up thence by the beginnings of the pulmonary veins. The histology, if the word may be so used, of these older writers was of a simple kind.

It was only a short while later that Marcello Malpighi (1628-1694), a professor in Bologna University, discovered what Harvey had failed to explain—namely, the transition of blood from arteries to veins by means of the capillary system. He was the first who, calling into his aid the newly invented microscope, opened up the way for a true grasp of the minute structure of the tissues and organs of the animal body, and in so doing opened up also a new branch of physiology. He was the first Histologist, and with the new histology came new ideas of the functions of many important parts of the body.

The microscope revealed to Malpighi features of structure transcending mere mechanical notions. He saw that the tissues in their minuter structure were governed by laws of their own, by laws different from those which determined the uses of machines; and thus there came to him the new conception of an animal morphology. In his brief epistles, Malpighi announced two discoveries of fundamental importance. In the first letter he described the vesicular nature of the lung and showed how the divisions of the windpipe ended in the dilated air vesicles. He thus for the first time supplied an anatomical basis for the true conception of the respiratory process.

A little later he turned his attention to the simpler lung

of the frog, and in this he had the happiness, calling into his aid the microscope, to see that minute but definite

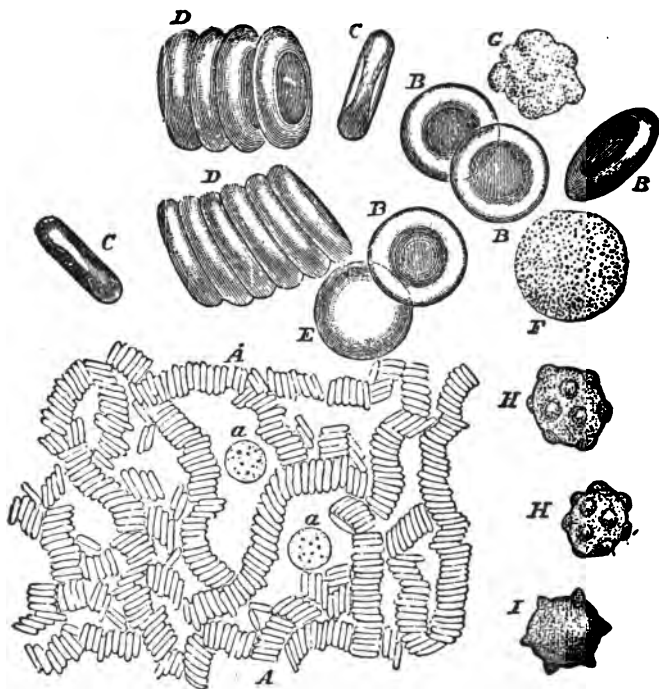


Fig. 9—BLOOD-CORPUSCLES. FIRST DESCRIBED BY LEEUWENHOEK

- A, Moderately magnified. The red corpuscles are seen lying in rouleaux; at a and a are seen two white corpuscles. B, Red corpuscles much more highly magnified, seen in face; C, ditto, seen in profile; D, ditto, in rouleaux, rather more highly magnified; E, a red corpuscle; F, a white corpuscle magnified the same as B; H, red corpuscles puckered or crenate all over; I, red corpuscles puckered at the edge only.

channels, the channels which we now call capillaries, joined the endings of the minute arteries to the beginnings

of the minute veins. This was the first observation of the capillaries. It made Harvey's work complete.

In another letter he says: "And I myself, in the omentum of the hedgehog, in a blood-vessel which ran from one collection of fat to another opposite to it, saw globules of fat, of a definite outline, reddish in color. They presented a likeness to a chaplet of red coral." He mistook, however, the nature of what he saw. What evidently were blood corpuscles he thought to be fat cells passing from the fatty tissue into the current of the blood.

After this, the first real accurate description of the red corpuscles is ascribed to Leeuwenhoek, who in 1674, in the *Philosophical Transactions*, gave an account of the red blood corpuscles in man, and in various papers carefully described the blood corpuscles of different animals, showing that while circular in mammals, they are oval in birds, frogs and fishes, and proving that in all cases the redness of blood is due to these red bodies.

Malpighi was no mere professor. His time was not spent wholly in the laboratory and lecture room. He was actively engaged in healing the sick; he was as familiar with the phenomena of disease as with the phenomena of the healthy living being. He brought to bear on the former the same clear intellect which he turned toward the latter, seeking to find out the causes of the events which he witnessed. He was as busy in the post-mortem room as in the dissecting theater, and his writings on the character and causes of disease justify the claiming for him the merit of having laid the foundation of scientific pathology.

Malpighi may also be regarded as, almost in the same degree, the founder of that great and important branch of biological science which is known as embryology.

Within a few years of the publication of Harvey's book anatomists became aware of a new set of vessels, of whose existence no one before had dreamed, vessels neither arteries nor veins; vessels containing not blood, but

either a milky or a clear limpid fluid, and carrying their contents not to but away from the tissues, carrying them, moreover, not to that great organ, the liver, which in the old view was the chief seat of all concoction, but directly into the venous blood stream and so to the heart, from thence to be distributed all over the body. That such a conception almost at once found general acceptance is, as we have just said, a striking proof of how rapidly and profoundly Harvey's work had influenced the views of physiologists. These were the vessels of the lymphatic system.

Aselli detected the presence of valves in these vessels and recognised that they hindered the backward flow. He saw clearly, indeed, that his newly discovered vessels were channels for conveying the chyle, the elaborated contents of the intestine, away from the intestine; but influenced, doubtless, by the accepted view that all the absorbed food must be carried to the liver, to be there elaborated into blood, he went wrong as to the ultimate course taken by these vessels; he thought he could trace them into the liver. It may here be noted in passing that Aselli in his treatise speaks of and indeed figures the cluster of lymphatic glands lying in the mesentery as 'the pancreas'; and this cluster of glands was afterward often spoken of as 'the pancreas of Aselli.'

State medicine, altho much advanced in the sixteenth century, was even more in the seventeenth, by the physicians of all civilized countries. Medical police were organized for public hygiene, giving out plague ordinances, advice relative to clothing and food, inspection of provisions, etc. The epidemic diseases of this period were many and very destructive to human life. Plague was, perhaps, the worst, altho typhus fever raged fiercely, especially during the Thirty Years' War. Malarial disease, dysentery, ergotism, scarlet fever and smallpox were others which carried off many people.

The clerical element having entirely disappeared from

the ranks of the public physicians, there was more opportunity for improvement in the standing of the lay profession. A special characteristic of the seventeenth century physician, in addition to their great zeal for science, is found in their frequent and intimate occupation with chemistry, mathematics and natural philosophy.

One of the old state books of that century enumerates the following practitioners of medicine: I. The Medical Profession proper: a. Medici in general: commissioned court, field, hospital and plague medici. b. Surgeons, barbers, regimental surgeons, oculists, herniotomists, lithotomists, bath-keepers. c. Superior sworn midwives, nurses. d. Apothecaries, druggists, confectioners and grocers.

II. Sundry Impostors and Pretended Physicians: Old women, village priests, hermits, quacks, executioners, calf-doctors, Jews, vagrants, musicians, rat-catchers, jugglers and gipsies.

Instruction in medicine assumed better conditions. Italy, which had for so long held first place in educational matters, lost hold, the lead being taken by France and the Netherlands. Clinical and bedside instruction were taken up and tried, but not with much success. Students still had some influence in the management of their curricula, but not to the same extent of the preceding century. Anatomy was studied more frequently upon human bodies, so that dissections were performed in most universities. Occupation with practical anatomy was, of course, still regarded by the higher physicians as a business unworthy of them. They left it to the inferior surgeons, and merely pointed out and explained themselves with a staff what the surgeon had exposed. Thus the surgeons were the best anatomists and teachers of anatomy.

CHAPTER VII

THE PERIOD OF SYSTEMATIZATION

It has been said that the eighteenth century was a continuation of the idealistic tendency of the sixteenth, interrupted by the seventeenth, which was not idealistic. The masses were released from most of their bonds and fetters, and the principles of independence and free right of development were established. The tendency was humanitarian rather than humanistic, revolutionary rather than reformative. The numerous wars had no great effect on the development of general medicine, except surgery. It is in Germany, France and England that works of real permanence are found, the revival of experimental physiology, development of physical diagnosis and scientific study of statistics.

In the eighteenth century is found an age of systems and theories, the outgrowth of the vast amount of new material gathered from the new sciences. These systems lived a short life, and in that brief span contributed somewhat to the advancement of medical science. No system, even if it be wrong, can retard the progress of medicine, unless, like the Galenic, it be prolonged over a great space of time. The saving grace of the systems of the eighteenth century lies in the fact that they did not degenerate into pure theory, but the art of observation was cultivated in a prominent manner, and was practiced carefully and soberly, aided by reason and the use of the natural senses.

The Eclectic System was founded by Boerhaave (1668-

1738), who was one of the greatest of modern scientists. He was a capable chemist, and so popular a lecturer in medical subjects that hearers came from all over the world. He was a splendid clinical instructor, and as a practitioner is considered by Baas the most famous man of his age. He was the first to give separate lectures on ophthalmology and to use the magnifying glass in examining the eye. His was a great character, free from vanity and selfishness.

The doctrines of Boerhaave do not form any really new system, but rather include many ideas of the earlier systems. According to Boerhaave, disease is that condition in which the bodily "actions" are disturbed or unsettled, and take place only with difficulty. The reverse of this condition furnishes his conception in health. Fever is the effort of nature to ward off death. Hence the nervous fluid flows too quickly into the muscles, and the heart contracts too rapidly, so that the blood flows too rapidly in the capillaries.

Digestion, like the circulation, is explained on mechanical principles. He says: "The antecedent causes of this acid acridity are: 1. Food consisting of farinaceous, acid and juicy, fresh, raw, fermenting or fermented portions of vegetables. 2. The want of good blood in the body which receives this nutriment. 3. Debility of the fibrous tissue, the vessels and intestines. 4. Lack of animal motion.

"Primarily, it has its seat chiefly in the localities of primary digestion, whence it slowly infects the blood and finally all the humors. It occasions acid eructations, hunger, pain in the stomach and bowels, flatulence, spasms, sluggishness of and various changes in the bile, and acid chyle. In the blood, it produces pallor, acid, chyle, and hence in women milk too prone to acidity, sour perspiration, acid saliva, and thus itching obstructions, pustules, ulcers; then excitement of the brain and nerves with resulting convulsions, disturbance of the circulation, and finally death. Hence its effects may be perfectly predicted

and the mode of cure may be known. The cure is effected: 1. By animal and vegetable food opposed to acidity. 2. By the fluids of birds of prey, which fluids resemble good blood. 3. By strengthening remedies. 4. By active movement. 5. By medicines which absorb, dilute, weaken or change the acid. The selection, preparation, dose and timely employment of these remedies depend upon the judgment of the physician as to the disease, its seat, the condition of the patient, etc. Hence it is clear why some diseases are common in boys, the indolent young women and certain artisans." In forming his system, Boerhaave was not unmindful of the doctrines of Hoffmann, and particularly of the influence which the brain and nerves exercise over the operations of the animal economy, altho he never fully appreciated their power.

In therapeutics, besides his efforts to sweeten the acid, to purify the stomach, and to get rid of the acridities, Boerhaave claimed Hippocrates and Sydenham as his models, but without being by any means exempt from hypotheses in his determination of the indications. He was, however, for his time, comparatively simple in his actual therapeutic prescriptions, altho the latter were often enough odd in their character, as the blood of birds of prey. His medicines were, at all events, less effective than his personal presence, which indeed is true, '*mutatis mutandis*,' of all treatment. It was Boerhaave who first permanently established the clinical method of instruction, and its diffusion was due to his pupils, particularly Haller and Van Swieten. His influence in a medico-historical point of view is greater than his real scientific importance would warrant.

George Stahl (1660-1734), a profound thinker, founded a system distinctly independent. It is dynamico-organic, pietistic and antagonistic. He makes the soul or '*anima*' the supreme principle. Stahl put forward and brilliantly maintained the view that all the chemical events of the living body, even tho they might superficially resemble,

were at the bottom wholly different from the chemical changes taking place in the laboratory, since in the living body all chemical changes were directly governed by the sensitive soul, '*anima sensitiva*,' which pervaded all parts and presided over all events. This resembles the "*archeus*" of Van Helmont. His fundamental position is that between living things, so long as they are alive, however simple, and non-living things, however composite, however complex in their phenomena, there is a great gulf fixed. The former, so long as they are alive, are actuated by an immaterial agent, the sensitive soul; the latter are not. Further, the living body is fitted for special ends and purposes; the living body does not exist for itself; it is constituted to be the true and continued minister of the soul. The body is made for the soul; the soul is not made for and is not the product of the body. When the body is diseased, the symptoms are the manifestation of the soul trying to restore normal movements in the organism.

As Baas says: "With this object the soul is frequently compelled to make powerful exertions. As the soul ordinarily employs the circulation and the capacity of the parts of the body for contraction and relaxation (*tonus*) as the route and instrument of its influence upon the body, so also in disease, where, in consequence of the necessarily hastened and increased activity of the soul, either the pulse is accelerated, the temperature rises, etc., in a word, '*fever*' makes its appearance, or spasmodic movements, '*convulsions*,' are developed. In the false movements within the organism lies also the main cause of sicknesses, but not in the numerous external influences assumed by others. Were the latter the case, the frequency of sickness and the number of diseases would necessarily be much greater than they, in fact, are.

"Since, too, the soul governs the organisms chiefly by way of the circulation, disturbances and stagnation in the latter are also main causes of disease. These disturbances arise most frequently from '*plethora*,' which plays an

important rôle in the system and the therapeutics of Stahl. To get rid of this plethora, the soul employs the means mentioned above; either fever, with its heat, by which the blood is imperceptibly driven out or dissolved, or convulsive movements, by which the blood is driven into certain parts and there visibly discharged.

"In childhood, plethora produces a pressure of blood toward the head, and the soul, as a compensation for this, provides a hemorrhage from the nose. During youth this blood-pressure is directed rather toward the chest, and is equalized by hemoptysis and pneumorrhagia and bleeding 'piles,' which Stahl considers a safety-valve of the utmost importance. From this time dates the very high estimation of 'hemorrhoids' and 'hemorrhoidal impulses,' the 'hemorrhoidal flow' which prevailed among physicians until a very recent period, and is the rule among the laity even at the present day. When this hemorrhoidal flow stagnates, it is by all means to be again started up. In the stoppage of this flow lie the chief causes of hypochondria and melancholy, as well as of all chronic diseases."

"Fever, as we have seen, was for Stahl a salutary effort of the soul to preserve the body. This was true even of intermittent fever (seen in malaria), and accordingly he never suppressed this disease with cinchona. On the other hand, inflammation was, in his view, a stagnation of the blood (an iatro-mechanical idea—and such ideas are accepted by him also in other directions), under the forms of erysipelas, phlegmon and its suppuration."

Stahl scorned anatomy and physiology, thinking them beneath his dignity, and swore boldly by the maxim that good theorists (among whom he was one of the chief) may be bad practitioners. He says, in sarcasm: "The structure of the meandering passages in the ear, of the anvil, the hammer, and the stirrup and—what a noble discovery!—the round ossicle (all bones for the mechanism of hearing), if it were unknown, would render the physical knowledge of the body very defective. But medicine,

that is, practical medicine, profits by this knowledge precisely as much as by the knowledge of the snow which fell ten years ago!"

In therapeutics, Stahl placed at the head the healing power of nature, which is identical with his "soul." "It is the simple truth that man has his physician in himself, that nature is the physician of diseases and offers a better prospect of curing diseases than the most successful apparatus of our art." For the rest, he follows his system here, too, with the utmost strictness. The soul, as it is the cause of all diseases, so is it that which cures them all. Therapeutics can, or rather should, act upon this alone; that is, upon the "movements" occasioned by it. If too strong, they must be restrained; if too feeble or utterly wanting, we must endeavor to strengthen them or to call them forth.

Venesection, of which Stahl made excessive use in acute as well as in chronic cases, is to be considered the main check upon these movements. He even recommended venesection as a preventive or prophylactic measure twice a year, and by it the people have been served and injured down to modern times. Beside venesection he ranked care to reestablish the hemorrhoidal flow by the use of irritating drugs, which Stahl in other circumstances discarded. To these measures were added his "balsamic pills" (aloes, hellebore, etc.), stomach-powder, etc., rostrums which brought him a lucrative business. In addition Stahl gave purgatives and emetics, diaphoretics and especially alteratives, including his favorite saltpeter. He discarded, however, many effective drugs (and particularly the poisons), above all the Cinchona (because by its astringent properties it suppressed the febrile state, which was in itself sanative), opium and ferruginous preparations and mineral waters, because Hoffmann recommended them.

Stahl's teaching, as summarized by Foster, was briefly this: "Learn as much as you can of chemical and physical processes, and in so far as the phenomena of the living

body exactly resemble chemical and physical events occurring in non-living bodies, you may explain them by chemical and physical laws. But do not conclude that that which you see taking place in a non-living body, will take place in a living body, for the chemical and physical phenomena of the latter are modified by the soul. The events of the body may be rough hewn by chemical and physical forces, but the soul will shape them to its own ends and will do that by its instrument, motion."

It was the reaction against the exclusively mechanical and chemical theories of the seventeenth century and has fulfilled its mission in the history of culture. As Spiess says in defense of Stahl's theories, "It was enough for Stahl, in contrast to his contemporaries, who were all too prone to utilize the laws of mechanics then alone known and the trifling chemical knowledge of that period, of which they were proud, and which they employed entirely too extensively in the explanation of the phenomena of life—it was sufficient, I say, for Stahl to have rescued life as a specific active force, at least for organized beings." He thus stands forth as the founder of 'animism,' which doctrine, tho his sensitive soul fell back later to the lower stage of 'a vital principle,' maintained itself in many minds through the two succeeding centuries and exists at the present day.

Friedrich Hoffmann (1660-1742) was the founder of the so-called Mechanico-dynamic System, which was held in high esteem by the most eminent physicians of that time. The train of thought in Hoffmann's system is as follows: "Our knowledge is finite, rooted in the senses and limited to what is perceptible by the senses; all final causes, however, are inscrutable. Forces and influences beyond the range of the senses, cognizable by metaphysical speculation, lie without its limits. Forces are inherent in matter and express themselves as mechanical movements, determinable by mass, number and weight. In the body also these forces express themselves by movement, as action

and reaction, contraction and relaxation, 'tonus.' Life is movement, especially movement of the heart; death the cessation of the movements of this organ, as the result of which putrefaction begins. Death and life are mechanical phenomena. Health is synonymous with the regular occurrence of the movements; disease a disturbance of the same. The contraction of the heart, the blood-vessels and animated fibers set in the motion the circulation of the blood and effect regular secretion and excretion, the chief phenomena of health. Digestion is the solution of food by means of the saliva and warmth, perspiration an effect of heat alone, and takes place not only through the pores, but also through the smallest vessels of the skin.

"The body is precisely like a hydraulic machine. Its movements are effected and maintained by that dynamico-material principle of fluid, but extremely volatile, constitution, 'the ether' (synonymous with nervous ether, nervous spirit, 'sensitive soul,' the pneuma of the ancient physicians). This acts in accordance with the laws, not of ordinary mechanics but of a higher and still uninvestigated science, and is in very small part derived from the atmosphere, but chiefly secreted from the blood in the brain. The 'movements' of the latter organ drive it, by way of the nerve tubules, throughout the whole body. This motor principle possesses conception and sensation and is the soul which alone perceives things. It forms and maintains the body in accordance with its idea, and each special particle of it has a conception of the composition and mechanism of the body. The chief reservoir and center of the ether is the medulla oblongata at the base of the brain."

Hoffmann's therapy was simple and designedly poor in drugs (according to the ideas of that time), but by no means free from theoretical views. The physician has, before all else, to regulate the disturbed movements, for nature is frequently not able to do this. But there are diseases which cure other diseases; that is, fever cures

spasms. Hoffmann divided drugs (which he held worked under mechanical laws) into those which strengthen or weaken, alter or evacuate. He was especially partial to the use of his own remedies and wine, particularly Hochheimer, which he considered the best of all wines, as the English, at his instance, do at the present day. Camphor he strongly recommended; likewise mineral waters, cold water, Seidlitz salt, cinchona and iron. He often practiced venesection and laid great stress upon the observance of prescribed diet, as absolute diet, milk diet, wine diet, exercise, etc. Poisons in general he rejected; the preparations of lead he absolutely discarded for internal use and desired to limit the employment of opium.

William Cullen (1712-1790), a Scotchman, was at first a barber, then surgeon, and after years of hardship he finally got his education at the university. Then for years he was a professor of chemistry and medicine. He founded a system of nervous pathology. The main foundation of Cullen's system is formed by the living solid parts of the body, not the fluids; the chief agents are the nerves. An undefined dynamic something, which is different from Hoffmann's material ether and the supernatural soul of Stahl and which Cullen calls "the nervous force," "nervous activity," "the nervous principle," is the proper life-giving element. He also calls this principle "the animal force" or "energy of the brain," in which he also includes the spinal cord. He believed that the soul of man is inseparably united with his brain.

The nervous principle produces spasm and atony. The former is not, however, always dependent upon increased nervous activity, but may also originate from feebleness of the brain, which is the center of nervous activity. The nerves are the conductors of the activity of the brain. Everything is effected through the brain and the nerves, and everything, including the causes of disease, works upon both of these. The causes of disease are chiefly of a debilitating character, but they awaken reaction and the

healing power of nature. Fever is such a reparative effort of nature, even in its cold stage, and its cause is diminished energy of the brain, often united with a kind of delirium, due to a contemporaneous spasm of the extremities of the vessels, which produces a reflex acceleration of the heart and a stimulation of the arteries.

The blood plays no part in fever, which is excited by weakening influences, as fright, cold, intemperance, the emanations of marshes or human beings, etc. Besides the spasm of the vascular extremities and the feebleness of the brain, there is also an accessory atony, which is propagated by sympathy to the tunics of the stomach and occasions the loss of appetite associated with all fevers. Both spasm and atony continue until the brain has recovered its ordinary activity, a result due to the increased activity of the heart, and recognised by the establishment of perspiration.

Cullen's explanation of the gout was famous. According to his view, this disease depends upon an atony of the stomach or organs of digestion, against which is set up periodically a reparative effort in the form of an inflammation of the joints. Gout is a general disease, but there is no gouty material. His therapeutics were simple, and, from his renunciation of the previous abuse of venesection, they were very salutary.

Anton de Haën (1704-1776), of The Hague, a pupil of Boerhaave, was the founder of the old Vienna school, a union of Hippocrates, Sydenham and Boerhaave. Its chief merits are in its practical and diagnostic services and in its generally sober observations. He believed, like Hippocrates, in the simplest possible treatment, united with careful observation. Nature must not be disturbed by medicines of a powerful action. He warmly embraced hygiene and prophylactic views. He reintroduced the thermometer and demonstrated that in the cold stage of fever an elevation of temperature, often considerable, could occur.

The school of Montpellier, led by Borden, maintained the existence of a general life of the body, which resulted from the harmonious working of the individual lives and powers of all its organs. These organs are associated one with the other, but each has a different function. The most important organs are the heart, stomach and brain. These regulate the life of the other organs. From them proceed sensibility and motion, the two chief phenomena of life. The nerves are the chief organs which, with the brain as their center, distribute and regulate motion and sensation throughout the body, but do not act in conformity with chemical and physical laws. The stomach presides over nutrition, the heart propels the blood and chyle through the body. Health is the undisturbed circulation of motion and sensation from and to the three centers of the body. There is no such thing as perfect health, for it fluctuates from moment to moment. Secretions and excretions, sleep and waking, muscular activity, the employment of the external and internal senses, all are subordinated to these three chief organs.

Animal magnetism was a theory advanced by Franz Mesmer (1734-1815), later called mesmerism. He claimed that there was some "magnetic fluid" existing everywhere throughout the world, and, of course, in man also, and this overflowed from the hand with a healing influence upon others, and that the sick were particularly susceptible. He erected a private institution, where he treated simpletons and credulous old ladies. He later went to Paris, where he was "the rage" for a long while and to the betterment of his pocketbook. Mesmerism is merely the application of hypnotism, such as may be practiced by any one. It is the result of a play on the imagination of the patient, who thereby renders himself more susceptible to suggestions which the hypnotist may offer. It has lately been applied to certain forms of hysteria and nervousness with great success.

Galvanism was considered the genuine "vital force," the

positive pole being identified with irritability, the negative with sensibility, and the theory was carried so far as to declare man the irritating and active pole and woman the sensitive and passive! Galvani himself had located the seat of electricity in the brain and he held that by means of the nerve-tubes it reached the whole body and especially the muscles, producing in them contractions analogous to the accidentally discovered twitchings of the frog. Disease was the disturbance of this electricity in the body.

Chemical and physical theories arose as the result of the advances made in chemistry and physics. The Phlogistic Theory is the theory of animal heat. According to this the free heat existing in the inspired air is incorporated with the body by means of respiration, and at the same time "phlogiston" is removed from the blood. Disease is the result of too much or too little heat. Against this arose the Antiphlogistic Theory, in which the newly discovered oxygen was accepted as the "vital force." Disease depended upon the appropriation of too much or too little oxygen.

The Brunonian System, founded by John Brown (1735-1788), was the most brilliant of the eighteenth century. According to Brown, life is not a natural condition, but an artificial and necessary result of irritations constantly in action. All living beings, therefore, tend constantly toward death. That irritations can compel life is their characteristic. Living beings, too, are capable of excitability, which is, indeed, inscrutable in its nature, but its seat in the muscles and the medulla of the nerves may be demonstrated. The latter is the cause of the processes which take place in the body, whether sound or diseased, and consequently of life itself.

Irritations are of two kinds, external and internal. To the external belong food, blood, the fluids in general, warmth, air, etc.; the functions of thought, feeling, muscular activity, etc., are to be considered internal irritations, which have the same action as the external. Moreover,

irritations are general or local. General irritations arouse excitement in the whole body; the local act first of all upon an individual part and subsequently upon the whole body. Health is an intermediate grade of excitement, diseases too high or too low a grade. The two are not conditions substantially different, but simple gradations of one and the same action upon the excitability.

Excitement is divided into different grades according to the degree of action of the irritation. The extreme grades of this scale are like the exhaustion and accumulation of irritability as the result of too great or too little power of the irritants and are death. The intermediate result is ordinarily weakness (*asthenia*), either direct or indirect. Direct *asthenia* depends upon the presence of an excess of excitability, accordingly upon too great an accumulation, of excitability the result of a deficiency of irritation. It is to be removed by new irritations, which reduce that excess to the normal proportion of health. Indirect *asthenia* is to be referred to an excess of irritation, by which excitability becomes exhausted. It is to be relieved by opposing a weaker irritation to the too strong causative irritation. The grades of excitability are always in inverse proportion to the excitement. Most diseases are dependent upon *asthenia*. *Sthenia* is more rarely a cause of disease and is the result of a less powerful irritation.

Brown's diagnosis requires no special symptomatology, but simply a consideration of the antecedent injuries and the earlier condition of the health, without any distinction between local and general diseases. It demands only the determination of the grade of diseases in accordance with the strength or weakness of the acting irritation. For this purpose some pupils of Brown drew up a kind of barometer of disease.

Like the system of Asclepiades, with those views (*Methodism*) Brown's doctrine, setting aside its change of terms, has the greatest similarity, the Brunonian system held substantially the position that it is not nature which

cures diseases but the physician. The latter must continue to irritate or weaken until the medium height of the barometer of irritation is again reached. Of all the therapeutic methods, that of Brown is the one most deeply sunken in theory, from which even the nearly allied system of Asclepiades was more exempt. It was a fatal principle when applied to practice. For how could one recognise, and by what means could he bring about, the medium height of the barometer of irritation? One should always aim at general effects and not desire those of a local character, and with this object in view, he should not limit himself to a single remedy, but rather employ several that "the excitability may be attacked generally and uniformly." The 'materies morbi' furnishes no indications for the treatment. The physician need not work for its expulsion, but merely allow it time to leave the body.

The pure Brunonian system, in comparison with other far less logical and ingenious theories, won immediately after its announcement only a few partizans and opponents, however great was the attention which it aroused on its publication. Perhaps the important occurrences of the period may have been partially responsible for this—an explanation which applies with particular force to France—but the disagreeable characteristics of its founder and the countermining of his enemies (especially the highly esteemed Cullen) contributed their share.

Philippe Pinel (1745-1826) founded a theory called Realism. He is famous for the efforts he made to improve the conditions of the insane and for his study and treatment of mental diseases. Pinel became of great importance in the development of general medicine by his principle of substituting exclusively the analytic, or so-called natural-scientific, method for the synthetic method heretofore in vogue. He sought to determine diseases by a diagnosis carefully constructed from the symptoms, a thing which he considered easy. He desired further to classify them in accordance with their pure symptoms, a

matter which he regarded as practicable, inasmuch as he considered "disease" a simple, indivisible whole, composed of chief symptoms, following each other with perfect regularity, and varying only in unessential collateral phenomena, and capable of classification like the objects of the natural sciences. Perhaps the artificial classifications of Linneus and others may have supplied him with models. Pathological anatomy he subordinated to the symptoms. Pinel, accordingly, regarded even fever as something essential. His classes, in the second place, are arranged according to the tissues. He divides diseases into fevers, inflammations, active congestions, neuroses, diseases of the lymphatics and the skin, and undetermined diseases.

It is interesting to notice that altho the eighteenth century was replete with systems and theories, they were not new ones and did not materially advance medicine or save human life. The systems were almost invariably based upon the theories of the preceding centuries, but the great error of these men lies in the fact that they did not appreciate that medicine, as the science of both healthy and morbid life, like life itself, cannot be compressed into a system.

CHAPTER VIII

THE CONTRIBUTIONS OF THE PRACTITIONER

THE steady advance of medicine and its allied sciences depended not so much on the great number of systems and theories that were springing up here and there, but upon the many physicians who shunned the ostentation of creating new systems. These were the men working along steadily, either in the laboratories on anatomy, physiology and chemistry, or at the clinics and bedsides, seeking always a way to alleviate pain and to cure disease. One of the latter was Auenbrugger (1722-1809), who in his own words can best describe his services to practical medicine:

"I here present the reader with a new sign which I have discovered for detecting diseases of the chest. This consists in the percussion of the human thorax, whereby, according to the character of the particular sounds thence elicited, an opinion is formed of the internal state of that cavity. In making public my discoveries respecting this matter I have been actuated neither by an itch for writing, nor a fondness for speculation, but by the desire of submitting to my brethren the fruits of seven years' observation and reflection. In doing so, I have not been unconscious of the dangers I must encounter; since it has been the fate of those who have illustrated or improved the arts and sciences by their discoveries to be beset by envy, malice, hatred, detraction and calumny. This, the common lot, I have chosen to undergo; but with the determina-

tion of refusing to every one who is actuated by such motives as these all explanation of my doctrines. What I have written I have proved again and again, by the testimony of my own senses, and amid laborious and tedious exertions; still guarding, on all occasions, against the seductive influence of self-love."

His invention was of great diagnostic importance in diseases of the chest, but its significance was not grasped until many years later. Altho the ear had been employed in auscultation and in the percussion of tympanites and ascites as far back as the ancients, no diagnosis of the diseases of the great viscera had been attempted in this way.

Diseases of the intestines were not much described, as the hemorrhoids and portal stagnation of Stahl were still strongly accepted. Diseases of the peritoneum were first studied by Morgagni and Walter. Diseases of the lungs were studied, but not successfully, being long obscure. "Dropsy of the chest" included many diseases which could not be separated from one another, as emphysema, hydrothorax, etc. Catarrh of the lungs and the bronchi were not differentiated, nor pleurisy and pneumonia, both being called peripneumonia, as in the days of Hippocrates. Morgagni was the first to clear these up.

Tuberculosis of the lungs was only fairly understood. Some of the English thought consumption due to an excess of oxygen in the lungs, and proposed to offset it with inhalations of carbonic acid gas. Diseases of the heart, pericardium and aneurisms were studied by Morgagni, but not much advance made. Diseases of the nervous system were carefully studied. Neuralgia of the face was known (also by the Arabians) and treated with electricity.

Diseases of the brain were developed a little. Morgagni first wrote of "meningitis." Robert Whytte told of "water on the brain." Hoffmann demonstrated the blood-clot in the brain of a person who died from apoplexy.

Epilepsy was studied by Tissot. St. Vitus' dance and hysteria were examined. The diseases of children received much attention. The anemias were described and better understood. Scurvy and gout were written about. Haller, by the injection of putrefying matter into the veins, proved the existence of "septic" poisoning, and prepared the way for the doctrine of septicemia. Pole and Dobson found sugar in the urine of diabetics.

Surgery attained, in this century, the rank of equality with so-called internal medicine, not only from the scientific, but also from the practical standpoint. Its higher representatives received the same social rank. The impulse to all this advance again proceeded from France, the headquarters of modern surgery. The surgeons of this time took up ophthalmology very extensively and cultivated it to such a degree that it soon became a specialty of high rank, practiced by eminent men. It had up to this point been in the hands of the charlatans. The English surgeons were famous for skill and daring and much of the advance is due to their good work.

The surgeons helped advance not only operative technique, but also anatomy and physiology. Cheselden, White, the Hunters and Bell were among those who made the English famous for surgery. Obstetrics was even more thoroughly cultivated than surgery. It was separated from surgery and assumed the dignity of a specialty, due mainly to the excellent work of the French.

There had been such an upheaval in the study of anatomy in the preceding century, that there was not very much more to investigate. But it was studied constantly and thoroughly, there being frequent additions to anatomical knowledge, of the more minute and less striking parts. The relation of anatomy to physiology was better appreciated, and anatomy began to be studied from that standpoint. Microscopic anatomy, also, was quiet as compared with the preceding century. Pathological and general anatomy were newly created.

A still more important acquisition of the eighteenth century in the fundamental sciences of medicine was the revival and study of experimental physiology. This revival, which marks an epoch in the history of medicine, was effected by Albert von Haller (1708-1777), of Berne, a distinguished scholar and thinker, a poet, botanist and statesman. His anatomical discoveries were made while working out his chief doctrines. He enriched the anatomy of the heart, while studying his doctrine of irritability in reference to that organ. He showed that the dura mater or covering of the brain formed the venous sinuses, and he thought the dura had no nerves in it; he studied the structure of the uterus and showed it was a muscular organ.

Of the highest importance were his researches on the mechanics of respiration, on the formation of bone, and on the development of the embryo; the latter indeed stands out as the most conspicuous piece of work on this subject between Malpighi and Von Baer, tho marred by the theoretical speculations attached to it. What is, perhaps, his greatest work, was the establishment of the doctrine of muscular irritability. In dealing with each division of physiology he carefully describes the anatomical basis, including the data of minute structure, physical properties, and chemical composition so far as these were then known.

In the physiology of the circulation, he studied the mechanism of cardiac motion. He believed that the internal mechanism was due to irritation, and on this based his Doctrine of Irritability.

In his physiology of digestion, he departed from his predecessors. According to him, saliva is neither acid nor alkaline; and so far from attributing to it the great virtues claimed for it by Sylvius and Stahl, he seems to regard its great use as being that of softening the food and helping deglutition.

Dwelling on the difficulty of obtaining gastric juice in

the pure condition, noting that acidity is often a token of the onset, and alkalinity of the advance of putrefaction, he concludes that pure gastric juice is neither acid nor alkaline; and while speaking of it as a macerating liquor which softens and dissolves the food, he refuses to regard it as a ferment. It is not a corrosive liquid, as are many acids, and tho it may be at times acid, the acidity is a token of the degeneration of the digested food, not of digestion itself, which "imparts to the food a wholesome animal nature"—i.e., gives it the beginning of vitality; and the characteristic of living animal tissues is, he urges, alkalinity rather than acidity.

Trituration he regards as a useful aid, especially where hard grains form a part of food, as in that of birds, but only an aid. "They have done well who have brought back to its proper mediocrity the power of trituration so immensely exaggerated." Bile he insists is not, as some have thought, a mere excrement. Retained for a while, and slightly altered during its stay in, but not formed by the gall-bladder, secreted, on the contrary, by the substance of the liver, partly perhaps from the blood supplied by the hepatic artery but mainly from that of the vena porta, bile is a fluid viscid and bitter, but not acid, and indeed not alkaline, a fluid which, as all know, has the power of dissolving fat and so acts on a mixture of oil and water as to form out of them an emulsion; it thus dissolves all the food into chyle. This view is almost entirely correct.

The old idea, handed down from the ancients, that the mechanism of respiration was due to the lungs contracting independently, he fought against, as he did not believe that air existed in the pleural sac, which would be necessary if the equilibrium be maintained in and outside the lungs. The most brilliant contribution of Von Haller to the physiology of the nervous system was his refutation of the doctrine of oscillatory motion of the nerves, and his administration of the death-blow to the doctrine of vital



VESALIUS, THE FOUNDER OF ANATOMY.

spirits. Haller proved that sensation takes place in the nerves, or in organs which contain nerves.

Glisson taught "irritability of the fiber" as well as of the fluids, under the influence of external and internal irritation—a doctrine which he discovered by the deductive method. But Haller proceeded to follow up this principle by the inductive method, proving its existence by experiment. But in contrast to Glisson, he demonstrated that this irritability was something entirely special, a simple peculiarity of muscular substance, and differing from sensation. He showed that muscle tissue will contract (being irritable) even when no nerves go to it, and set up a long dispute as to whether nerve or muscle involved the contraction. It must not be forgotten that in all his researches, Von Haller did not have the aids and accessories of modern physiologists, so that he deserves the more credit for his great work.

Pathological Anatomy was established by Morgagni, of Italy (1682-1772). He was the first to devote attention extensively and thoroly to the anatomical products of common diseases. Prior to him, only the rare and very evident lesions of disease were noted and discussed. He studied the clinical pictures, the history of the symptoms, and the course of the disease as well, thus making his observations complete. He erred, however, in regarding the products of diseases as their cause. He showed how important it is to know the steps in the pathological conditions of any organs in a disease, how it aids in diagnosis of the affection, and how it helps in the treatment. He was the first to appreciate a nervous reflex, especially that of sneezing, although he knew nothing of the sympathetic nervous system.

Morgagni studied the action of alcohol on the human system. He pointed out that the excitation of the heart was due to reflex action, following overdistention of the arteries. This overdistention, or increased tension, led to degenerations in the arterial walls. Thus he inves-

tigated aneurism and showed the changes that take place in an artery thus diseased, and he recommended special and careful diet as a treatment for early aneurism. In the study of tuberculosis, he was most penetrating. He insisted that it was contagious, and he believed in it to the extent of refusing to do autopsies on that disease. He taught and believed in the early operation for the treatment of cancer. He was a strong opponent to venesection.

General Anatomy was founded by Marie Bichat (1771-1802). He was a great teacher of anatomy. Through his wonderful mental fertility and power, and in spite of his early death, he wrote, in the few years of his life, a great number of important works—they include nine volumes. As an evidence of Bichat's enormous activity it may be stated that in a single winter he examined 700 bodies. His chief works were the "*Traité des membranes*" (1800), "*Anatomie générale*" (1801) and "*Anatomie pathologique*."

From Bichat's general and pathological anatomy a new tendency in medicine—that tendency which it manifests to-day—took its origin, as Baas points out. Bichat's genius, masterly mental power and charming gracefulness of exposition, founded chiefly the realistic and pathologico-anatomical epoch. He uttered the famous apothegm, "Take away some fevers and nervous troubles and all else belongs to the kingdom of pathological anatomy."

Bichat established the tendency of similar tissues to similar anatomical forms of disease. This last division is connected with Bichat's creation of general anatomy. He distinguished general tissue-systems, found everywhere in the body, as cellular tissue, the nervous system of animal and organic life, the arterial system, the venous system, the system of exhalant vessels and lymphatics; and special tissue-systems, peculiar to certain parts exclusively, as the osseous, medullary, cartilaginous, fibrous and fibro-cartilaginous systems, the animal and vegetative muscular system, system of serous and

mucous membranes, system of synovial membranes, glandular system, dermoid system, epidermoid system and the hairy system. These twenty-one tissues, selected without the aid of the microscope (which Bichat did not employ), were distinguished as simple and similar elements of the body, like the elements of chemistry, and like the cells which Virchow chose for his elements. They were assigned to general anatomy, while, on the other hand, descriptive anatomy had to do with their different combinations. Thus, according to Bichat, the stomach, as the subject of descriptive anatomy, is composed of a serous, mucous and organic muscular coat. The simple membranes are the mucous, serous and fibrous; the compound membranes are formed by juxtaposition of these, and are called fibro-serous, sero-mucous and fibro-mucous, uniting in themselves one or more of the properties of the simple membranes.

Bichat overthrew the ontological and speculative tendency of medicine, placed "facts" in the front rank and banished ideas and "ideologists" from the science. "If I have gone forward so rapidly, the result has been that I have read little. Books are merely the memoranda of facts. But are such memoranda necessary in a science whose material is ever near us, where we have, so to speak, living books in the sick and the dead?" "Let us halt when we have arrived at the limits of the most careful and thoro observation, and let us not strive to press forward where experience cannot show us the way"—a sentiment which certainly does not accord with his earlier vitalistic views. Bichat was the first who claimed for medicine the rank of an "exact" science. "Medicine was long thrust forth from the bosom of the exact sciences. It will have the right to be associated with them, at least as regards the diagnosis of diseases, as soon as we shall everywhere have united with the most thoro and rigorous observation, the investigation of those changes which our organs suffer."

In the course of the further development of such views, and in consequence of the great sympathy extended to them everywhere, a new one-sidedness seized upon the medicine of the last century—a one-sidedness quite as great as the by-gone and partial idealism of the eighteenth century. This was the thoroly realistic method, which gives to medicine the rank of one of the natural sciences, and finally goes so far as to desire to interpret and explain by pure realism even the mental characteristics.

Inoculation was no new thing when introduced during the eighteenth century. The communication of natural smallpox to the healthy, in order to protect them from the natural disease, reaches back into hoary antiquity. The custom is mentioned among the Indians in the Atharva Veda. The operation was always performed by the Brahmins, who employed pus produced by those who had been inoculated with natural smallpox one year before, and also the pus of these secondary inoculations. They rubbed the place selected for operation—in girls the outside of the arm, in boys the outside of the forearm—with wool until red, scratched these places several times with knives for a space about an inch long, and laid upon them cotton soaked in variolous pus and moistened with water from the Ganges.

Before inoculation a preparatory course of diet lasting for four weeks was considered necessary. The inoculation was performed in the open air, and the inoculated were required to remain out of bed to sprinkle themselves morning and evening with cold water. If fever made its appearance the sprinkling was discontinued and the inoculated might at most stretch themselves before the threshold, and must eat sparingly. The Brahmins traveled about the country to perform inoculation, and the operation was practiced in the beginning of spring. Under the influence of such excellent hygienic regulations the results were for the most part favorable.

Among the Chinese the so-called "pock-sowing" was

practiced as early as 1000 B.C. by introducing into the nasal cavities of children, aged three to six years, a pledget of cotton saturated with variolous pus. The Arabians had a "pox-sale." Pus from a patient suffering with small-pox was purchased for raisins and inoculated with needles. The Circassians, too, by means of needles, inoculated handsome girls upon the cheek, right wrist, left ankle, and over the heart, in order to preserve their beauty.

In the states of North Africa incisions were made between the thumb and index-finger; among the negroes inoculation was performed in the nose, and in Denmark, Scotland, the Auvergne and other places, this operation was performed at an early period. The employment of the inoculation of natural smallpox by the Greeks of Constantinople, where the custom had been long naturalized and practiced by old women instructed in the art, exercised a most important influence upon the West.

But it remained for Edward Jenner to solve the problem. He demonstrated that a simple attack of mild, never fatal cowpox, deliberately acquired, would serve as a protection against the fatal smallpox. His discovery was the result of his genius for original investigation. On the 14th of May, 1796, vaccine matter was taken from the hand of a dairy maid and inserted into the arms of a healthy boy of eight. He went through an attack of cowpox in regular fashion; then, two months later, Jenner inoculated him with real smallpox pus, but with no deleterious result. In his very complete and explicit report, he says:

"The deviation of man from the state in which he was originally placed by nature seems to have proved to him a prolific source of diseases. From the love of splendor, from the indulgences of luxury, and from his fondness for amusement he has familiarized himself with a great number of animals, which may not originally have been intended for his associates. The wolf, disarmed of ferocity, is now pillowed in the lady's lap. The cat, the little tiger

of our island, whose natural home is the forest, is equally domesticated and caressed. The cow, the hog, the sheep, and the horse, are all, for a variety of purposes, brought under his care and dominion.

"There is a disease to which the horse, from his state of domestication, is frequently subject. The farriers have called it the 'grease.' It is an inflammation and swelling in the heel, from which issues matter possessing properties of a very peculiar kind, which seems capable of generating a disease in the human body (after it has undergone the modification which I shall presently speak of), which bears so strong a resemblance to the smallpox that I think it highly probable it may be the source of the disease.

"In this dairy country a great number of cows are kept, and the office of milking is performed indiscriminately by men and maid servants. One of the former having been appointed to apply dressings to the heels of a horse affected with the 'grease,' and not paying due attention to cleanliness, incautiously bears his part in milking the cows, with some particles of the infectious matter adhering to his fingers. When this is the case, it commonly happens that a disease is communicated to the cows, and from the cows to the dairymaids, which spreads through the farm until the most of the cattle and domestics feel its unpleasant consequences. This disease has obtained the name of 'cowpox.'

"Inflamed spots now begin to appear on different parts of the hands of the domestics employed in milking, and sometimes on the wrists, which quickly run on to suppuration, first assuming the appearance of the small vesications produced by a burn. Absorption takes place, and tumors (enlarged lymphatic glands) appear in each axilla.

"The system becomes affected—the pulse is quickened: and shiverings, succeeded by heat, with general lassitude and pains about the loins and limbs, with vomiting, come on. The head is painful, and the patient is now and then even affected by delirium. These symptoms, varying in

their degrees of violence, generally continue from one day to three or four, leaving ulcerated sores about the hands, which, from the sensibility of the parts, are very troublesome, and commonly heal slowly, frequently becoming phagedenic, like those from whence they sprang. The lips, nostrils, eyelids, and other parts of the body are sometimes affected with sores; but these evidently arise from their being heedlessly rubbed or scratched with the patient's infected fingers.

"Thus the disease makes its progress from the horse to the nipple of the cow, and from the cow to the human subject. Morbid matter of various kinds, when absorbed into the system, may produce effects in some degree similar; but what renders the cowpox virus so extremely singular is that the person who has been thus affected is forever after secure from the infection of the smallpox; neither exposure to the variolous effluvia, nor the insertion of the matter into the skin, producing this distemper.

"I have often been foiled in my endeavors to communicate the cowpox by inoculation. An inflammation will sometimes succeed the scratch or puncture, and in a few days disappear without producing any further effect. Sometimes it will even produce an ichorous fluid, and yet the system will not be affected. The same thing we know happens with the smallpox virus.

"The very general investigation that is now taking place, chiefly through inoculation (and I again repeat my earnest hope that it may be conducted with that calmness and moderation which should ever accompany a philosophical research), must soon place the vaccine disease in its just point of view. The result of all my trials with the virus on the human subject has been uniform. In every instance the patient who has felt its influence has completely lost the susceptibility for the variolous contagion; and as these instances are now become numerous, I conceive that, joined to the observations in the former part of this paper, they sufficiently preclude me from the neces-

sity of entering into controversies with those who have circulated reports adverse to my assertions, on no other evidence than what has been casually collected."

It was not long before the opposition to the practice of vaccination took definite form, and it has continued down to this very day. It is opposed, however, only by those who will not seek statistics, which readily prove the enormous benefit that Edward Jenner conferred on humanity. Smallpox in epidemic form is unknown where vaccination is compulsory.

Another great advance in the prevention of human suffering was begun by Philippe Pinel in 1792. While in charge of the Bicêtre Hôpital he removed chains from the insane patients, and instituted a rational and humane treatment, such as is adopted to-day.

Throughout the eighteenth century an incredible number of strange and useless remedies were regarded as efficacious, such as mummy, millepedes, wood-lice; and even amulets were found in shops. Instead of simplifying the materia medica, a great many new drugs were added. Three remedies—or rather three therapeutic methods—require to be more carefully considered, since two of them during the eighteenth century began to be methodically and generally employed and scientifically studied, and the third was revived in a new form.

It has already been stated that the ancients, from the days of the Asclepiadæ, employed the waters of healing springs, mineral waters, often too frequently—Archi-genes had the patient drink as much as fifteen pints for the relief of stone. Indeed waters were even classified according to their constituents as alum-waters, sulphur-waters, chalybeate waters, bituminous waters, etc. The Italian physicians of the last half of the Middle Ages prescribed these waters. At a later period mineral waters were drunk still more frequently, indeed in considerable quantities, for at that time, even more than to-day, the excellence and efficacy of the water was judged by its

strength, particularly its cathartic effects. Paracelsus exercised a great influence upon the theory and employment of mineral springs (particularly those of Pfeffers, Gastein, etc.), and it is one of his chief services that he subjected the learned medicine of his day (which thought itself safe only in guilds and study-rooms) to the test of living observation and actual life, and employed chemistry in medicine, particularly also as it related to the question of mineral springs. As the science of chemistry itself was improved, the subject of mineral waters likewise enjoyed increasing attention.

The use of ordinary water as a remedial drink and in the form of (cold and tepid) lavations and baths for the cure of diseases, especially those of a febrile character, first made its way into German practice in the eighteenth century, tho it had been in use among other nations at an earlier period.

Even Hippocrates permitted baths in febrile diseases, tho rather tepid baths than cold. He was particularly fond of these in pneumonia, to mitigate the pain and facilitate expectoration and respiration. It is remembered that Musa cured the Emperor Augustus by means of cold baths, after warm baths had failed to produce any benefit. Asclepiades, Charmis of Marseilles, Agathinus, Herodotus, Celsus, Aretæus, Aëtius and others likewise employed cold water, most frequently in the form of affusions in the case of epileptics and lethargic patients, and as lavations and cold dressings upon the head in typhus. Galen, like Hippocrates, was no great friend of cold lavations and baths, tho he employed the former in the fevers of young people, excluding hectic fever. Among the Arabians, Rhazes recommended cold lavation and dipping in cold water in cases of smallpox and measles. Avicenna followed Galen, and regulated his employment of cold in accordance with the age, constitution and season of the year. The American Indians also practiced hydrotherapy in the treatment of yellow fever.

The epidemics of the eighteenth century, while not so severe as those of the preceding centuries, were frequent and extensive enough to create new problems for investigation and treatment. Plague was still seen in northern Europe; typhus fever was prevalent mostly after the wars; typhoid fever was first described in this century; malaria gave rise to great epidemics; dysentery, ergotism and diphtheria were very common. Diphtheria was particularly prevalent and deadly. Smallpox has diffused generally over all the world. In 1770, smallpox carried off 3,000,000 in the East Indies. Yellow fever was mostly confined to America. Hospitals during the whole eighteenth century were undesirably managed. "Hospital fever" never left them, as there was no hospital hygiene. Many hospitals contained large beds, occupied often by from four to six patients, and the mortality was rarely less than 20 per cent. Almost all who underwent operations, especially amputations, died. However, with the introduction of clinical instruction for students, conditions became improved.

The physician of the eighteenth century was even in externals distinct professionally, at least on festive occasions, from other men, and was distinguished, as are many modern "precise followers" of Æsculapius, by the fashionable cut of his clothing, his universal greetings, rapid gait, and amiability. Usually a thermometer, stethoscope, or percussion-hammer is described as peeping out of his pockets. The English physician had become a man of standing and took his rank with the parson and the squire.

CHAPTER IX

NINETEENTH-CENTURY THEORIES

THE beginning of the nineteenth century marks one of the most important movements in the history of all sciences, especially medicine. There was a great upheaval in all things, intellectual and otherwise, due mostly to the terrible revolution in France. After the peace, scientific study of all the branches began to assume wonderful proportions, especially in chemistry, histology, pathology and clinical instruction. The physicians and scientists of other countries flocked to Paris and there learned the new method of investigation and research—that is, experimentation. These new ideas and methods were carried to other countries and stimulated the development of science.

The eighteenth century regarded as its chief task, the rescue of the people from the medieval restrictions and limitations, particularly the spiritual side of life. On the other hand, the nineteenth century struggled almost extravagantly for the accomplishment of the economical or material demands for existence. This was seen in the many revolutions and wars for that purpose, abolishing slavery and placing in the foreground the individual, exposing him to the test of freedom.

Over the medicine of the present day the natural sciences have attained a control which is even more absolute than that seen in the seventeenth century. Buckle says regarding the cultivation of the natural sciences: "It

cannot, however, be concealed that we manifest an inordinate respect for experiments, an undue love of minute detail and a disposition to over-estimate the inventors of new instruments and the discoverers of new but often insignificant facts." In another place he says, "In vain do we demand that the details be more generalized, and reduced into order. We want ideas, and we get more facts. We hear constantly of what Nature is doing, but we rarely hear of what man is thinking. We are in the predicament that our facts have outstripped our knowledge and are now encumbering its march."

The theory of excitement was a modification of Brunonianism and was one of solidism. According to this theory, life depends upon irritability, which is inherent in the organism as an independent capacity. Thus two things, irritability and organization, are taken into consideration, while Brown recognised only the former. The grade of irritability determines the condition and behavior of the body, and health consists in moderate irritation and moderate excitability. Another offshoot of the Brunonian theory, far worse, was the "New Italian Theory." Its author was Rasori, of Milan. Its bad effects were the more evident and deplorable because when applied to the treatment of diseases, humanity must needs suffer. He taught that the diagnosis of diseases cannot be made from the symptoms, but solely from the remedies which benefit them or make them worse. Venesection is regarded as the most reliable diagnostic means. If it be beneficial, a certain condition exists which calls for certain medicines. If, after twice performing venesection, there is no benefit, the disease must be treated on other lines. Enormous doses of medicine were given, often interfering to an alarming extent with the process of healing.

In direct opposition to this system of medicine was early homeopathy. The action of drugs on healthy persons becomes the guide for a selection of remedies with which to treat disease. Accordingly, for the removal of a

given group of symptoms, that remedy must be selected which when given to a healthy person has produced the same, or at least a similar, group of symptoms. The homeopathic physician thus is required to know thoroly and accurately the effect of every drug on the human system; must know every symptom group, so as to apply the correct remedies, working thus on the theory "*similia similibus curantur*," and thus works with a complete knowledge of what he is doing. Samuel Hahnemann (1755-1843), of Meissen, was the founder of this school. By long study he came to the conclusion that all diseases were general, none local. He discovered four hundred and twelve symptoms of the "*psora*," or itch, which had its chief symptoms in the skin, and occasioned "so many secondary symptoms, that at least seven-eighths of all chronic complaints arose from this single source." He claims that *lycopodium* in extremely minute doses sets up a wonderful group of symptoms—falling of the hair, confusion of thought, eruptions, etc. In therapeutics, there are specifics only, and their efficacy is added to by dilution.

A single dose of a properly chosen specific frequently cures immediately. In the administration of homeopathic medicine the strictest diet must always be maintained. An offshoot of this early school of homeopathy was a doctrine called *Isopathy*. According to this, like was to be cured by like, no matter how nauseous or abhorrent to the taste. It occasioned attacks on its parent system and lived only a short life. Modern Homeopathy, however, has developed to no inconsiderable magnitude, and possesses many followers to-day whose reputation is often not less than the allopath. But even more important is the beneficial effect Hahnemann's work had in modifying the giving of large doses of potent drugs.

François Broussais (1772-1838) advanced a theory which he called *Physiological Medicine*. According to him, life depends upon external irritation, especially that

of heat. The latter sets up in the body peculiar chemical reactions, which maintain regeneration and assimilation, as well as contractility and sensibility. When these functions, which are supported by heat, cease, death comes on at once. Health depends upon the moderate action of the external irritants; disease upon their weakness or on their exceptional strength. Diseases originate from local irritations, proceeding from a certain diseased organ, or part of an organ, particularly from the heart, and often from the mucous membrane of the stomach and intestines, and these irritations diffuse themselves throughout the rest of the body through sympathy and by way of the nervous system. Every irritation which through sympathetic irritation of the heart produces fever, has become an inflammation, and the judge of this is hyperemia. The famous "gastroenteritis" is the most usual result of irritations of the brain. Through complications, it causes typhus and all other so-called infectious diseases. He denied the existence of specific morbid poisons. This "gastroenteritis" or "basis of pathology," he divided into two classes: If gastroenteritis predominates, it is accompanied with pains in the gastric region, and sudden vomiting of food and drink. If, however, the enteritis (not the stomach, but the intestine) is the chief lesion, great thirst, a sensation of internal heat, a sensitive abdomen, a rapid hard pulse, and a coated tongue are the chief phenomena.

In therapeutics Broussais believed that the physician is the lord of Nature. He must anticipate disease, particularly the gastroenteritis, against which all his efforts must be exerted. For this purpose, the antiphlogistic or weakening method is best. Febrile and inflammatory diseases he treated by the withdrawal of nourishment, carried to the extreme. He preferred, as the most efficient, antiphlogistic treatment, in place of venesection, which he strongly approves of, the employment of leeches, applying them to the gastric region. In robust individuals, thirty to fifty might be applied at once. In rheumatism and gout,

they were applied to the joints, and to the pit of the stomach.

The French School of Pathological Anatomy helped to advance medicine. It taught that pathology was pathological anatomy, while aiming to elevate the latter science into a "clinical anatomy," requiring the physician to search his patient for the changes of pathological anatomy. It required him to remove the products of the disease, rather than try to cure or remove the cause of the disease. The living patient became a mere subject for diagnosis and local therapeutic investigation. Many diseases were therefore considered incurable, and the desire and ability to cure disease were weakened.

Functional or dynamic disturbances were disregarded, while diseases of the fluids of the body were at first almost entirely forgotten, these errors being due to the fact that on autopsy no lesions were discovered. The patient was treated rather as a living cadaver, not as a being endowed with vital forces. But if the practice of medicine lost by these methods, on the other hand, knowledge of the changes produced in the body by disease was greatly increased.

The School of Natural Philosophy was founded in Germany. It was a purely speculative system, full of scholastic phrases. The school brought forth mainly a philosophy of medicine, rather than philosophical medicine. The School of Natural History followed. Baas claims that this was the expression of the turn which medicine was compelled to take to escape from the after-effects of the one-sided, ideal or systematizing tendency of the eighteenth century (of which natural philosophy was the final product), and to enter upon the realistic or positive tendency of science and culture in the nineteenth century in both medicine and the other sciences. It shows everywhere its mediatorial position between the old traditions and the most recent times. Thus, for the purpose of careful observation, it fostered, indeed, the ancient Hippocratic

diagnosis and method, by which it preserved its connection with the earlier medicine, and which the later school of natural science almost entirely set aside. In addition, however, it cultivated considerably the physical, and particularly the microscopic, diagnosis adopted from France. Indeed this school gave a decisive impulse to microscopic investigation in general, so that Virchow, one of its scions, subsequently founded upon it his cellular pathology, and thus elevated the microscope to the fundamental instrument in pathology and pathological anatomy.

The attempt was made by this school to classify diseases "naturally," into classes, families, species or kinds, such as in botany. There were some physicians in this school who later considered diseases to be genuine second organisms in the diseased body.

The new Vienna school was a continuation of the pathologico-anatomical school of Paris, greatly elaborated upon and added to. The leaders of the school had at their disposal over a thousand bodies annually to dissect, so that, as a matter of course, pathological anatomy was utilized from the standpoint of statistics. The microscope and chemistry were added for further study. Later the introduction of the laws of sound into the interpretation and conception of physico-diagnostic phenomena was made by Joseph Skoda. Skoda, by his views on physical diagnosis, showed himself an independent spirit who got his impulse from France, but far outstripped the French diagnosticians. On the other hand, practical medicine in his hands degenerated again into simple diagnosis. Not long after this physiology was utilized to explain pathology.

Henle defines the duty of the physician to be the prevention and cure of diseases. Here two methods of proceeding are to be distinguished, the empirical and the rational (theoretic, physiological). The latter is likewise the method of physiology; it is the method of all experimental sciences and particularly of the natural sciences. Moreover, the genuine scientific spirit is said to consist not

in ignoring or scorning philosophy, but "in the conscious and provisional renunciation of the knowledge of the first cause of things, because the time of proof is not yet past." "Accordingly if the collection of experiences is the chief thing, yet hypotheses must form a balance to its instability."

"In experimenting we fix arbitrarily the cause, so far as possible, and by observing the results we assure ourselves of the correctness of our conclusions. In this process the so-called localization of symptoms—that is, the search for the organ from which the symptoms proceed—is aimed at, but in addition, too, a knowledge of the quality of pathological changes, by a comparison of the altered form and composition with the normal. Pathology owes its weightiest facts to the employment of the microscope and to organic chemistry." Moreover, the hypothesis of a vital force is admissible and is just as good or as weak as that of electric attraction or of gravitation.

Disease is "a deviation from the normal, typical—*i.e.*, healthy—process of life, a modification of health, a removal from the relative norm. The essence of disease, however, is an expression of typical force under unwonted conditions." Disease, too, like life itself, is a process. Diseases are anomalies of this process. Any alteration which completely abolishes this process occasions not disease but death. Death is the cessation of the interchange of material. The termination in health follows spontaneously or through artificial or accidental influences. The transition to health ensues gradually in most chronic and in many acute diseases; in others, especially in acute diseases, the symptoms disappear suddenly. The first and slower method is called lysis, the last method crisis—the latter term a relic handed down from the mythical beginnings of medicine. A critical secretion is, in the main, nothing more than a secretion belonging to the stadium of the crisis. "The belief in crises, according to Henle, stands upon the same footing as belief in the devil. That

the exorcist had expelled a devil was demonstrated by the foul odor left behind by the evil spirit. The odor was a fact; that it could be diffused in no way except by the devil was perfectly self-evident." The same was the case with critical perspiration and such matters.

The modern chemical system, in opposition to the chemical system of the eighteenth century which was founded on inorganic chemistry, was the result of the active researches and discoveries in organic chemistry, and upon it the present theory of metabolism is based. According to this theory the physical changes in the body, so far as they cannot be classified as mechanical processes, are nothing more than oxidation or combustion of the elements of the body, effected by the oxygen in the blood, from inspired air; the body is a living retort or test-tube. The parts of the body were supposed to be destroyed and then regenerated. This process of oxidation is twofold, depending upon the two great classes of food-stuffs which compose the body or are taken into it. The respiratory foods (hydrocarbons, fats) are burned in the lungs during respiration and chiefly excreted there as carbonic acid. The so-called nutritive materials (nitrogenous, blood-forming foods), which compose the tissues proper, are consumed in the tissues themselves and are discharged as urea in the renal secretion.

Animal heat, they claimed, was the result of the processes of oxidation going on constantly within the body. The one class of foods, albuminous or nitrogenous, serves for the formation of the blood and construction of the large parts of the body, the other class is similar to ordinary fuel and serves mainly for the production of heat.

Fever was regarded as an abnormal increase in the process of combustion, disease a defect in this process. If one group of these materials is missing, therapeutic measures are indicated to increase the food of this sort and thus supply the deficiency. The theory regards the living body from the viewpoint of a chemist, to the chemi-

cal laboratory and chemical analysis, and does not pay sufficient attention to the adaptable side of physical life nor to the ever-changing and powerful influences in which the body is always placed. Yet the theory was of great importance in that it placed dietetics once more in the foreground.

Modern cellular vitalism was the result of the researches of Rudolph Virchow, born 1821. Then later, through the works of Beale, Louis Agassiz, Sharpey, Hassall, Bastian, Tyndal, Huxley and others, every organized structure of the living body was subjected to microscopic analyses and found to be composed of individual cells, varying in size and shape, and performing a great variety of functions, but all composed essentially of an organizable substance recognised as the physical basis of life and called by some investigators protoplasm and by others bioplasm. Its most distinctive attribute is its vital capacity to grow and multiply or propagate itself. Thus they found all living bodies, both animal and vegetable, composed of protoplasm aggregated in minute forms called cells and united in various ways to constitute all the organized matter in the fluids and solids of living bodies.

The theory is merely a modified employment of the old idea of the "vital force," referring the latter to the concrete, minutest parts, the so-called "corporeal" elements. "Every animal appears as a sum of vital unities," this school declared, "each of which bears all the characteristics of life. The characteristics and unity of life cannot be found in any determinate point of a higher organization,—e.g., in the brain of man—but only in the definite, ever-recurring arrangement which each element presents. Hence it results that the composition of a large body amounts to a kind of social arrangement, an arrangement of a social kind in which each of a mass of individual existences is dependent upon the others, but in such a way that each element has a special activity of its own, and that each, altho it receives the impulse to its own activ-

ity from other parts, still itself performs its own functions."

The cell is thus the actual, ultimate, proper morphological element of every vital manifestation—"omnis cellula e cellula"—and the action takes place within the cell itself. The most constant part of the cell is the nucleus or central spot of the cell. Next to the cell is the membrane. The development or increase of cells is continuous; it takes place by continual growth of cells, and a new growth of cells presupposes existing cells.

The reception of nutritive materials is effected through the activity of the tissue elements in the form of an attraction of this material by the tissues themselves in proportion to their needs. Virchow taught that certain tissue elements have the power to extract certain materials, thus possessing specific affinity; thus the liver extracts sugar and bile from the blood. He also held that the vascular system was completely closed by membranes.

In the doctrine of inflammation Virchow, in addition to the four well-known phenomena of inflammation—redness, heat, swelling, pain—took up the disturbance of the function of the diseased part. In fact, he laid most stress on this as the most effective symptom.

Many important points of the vitalistic cellular theory have already been disproven in the light of more recent microscopic interpretations. It is the one great theory on which its author did not try to build a system of therapeutics. One of the results of this theory was the formation of the school of natural sciences, which seeks chiefly by the aid of pathological anatomy and microscopy to render medicine an "exact" science. The hygiene school also advanced to the front. The tendency of this latter school was to split up medicine into specialties and increase the number of subordinate branches.

CHAPTER X

MODERN TREATMENT OF DISEASE

THE Modern Parasitic, or Germ Theory, had its origin shortly after the invention of the microscope, when a former school maintained that diseases were due to microscopic organisms and animals. In the present day, however, the lowest order of plants is believed to be the infecting material in certain infectious diseases. Haller, some years ago, injected putrid matter into the veins of an animal and caused pyemia and then became the creator of experimental pathology. Parasites were discovered causing diseases in animals and plants; in skin and scalp diseases the modern theory of the production of diseases through infection found further support in the investigations relative to the processes of fermentation and putrefaction, with which the processes of disease were at once compared.

Pasteur demonstrated that fermentation and putrefaction were caused not by chemical ferments, as Liebig thought, but were merely the vital processes of lower organisms. These he divided into two great classes—aérobés, which work only in the presence of oxygen, and anaérobés, which work without oxygen but do not survive after action. Wound infections were for the first time considered infected from the outside. Robert Koch demonstrated the development of bacteria from spores. At the present day no consistent theory exists which fully explains parasitic action in disease. Certain of the lower fungi, as parasites

within or upon the body, cause diseases of the infectious type. There are two theories concerning the *modus operandi* of these parasites. One is that by the development and growth of these germs in the system the body is deprived of its nutriment and life endangered by the lack of oxygen. According to the other theory, these parasites give off in their own metabolism poisonous products (toxines), which interfere with the action of normal cells.

Elie Metchnikoff, of Odessa, observed that the wandering cells—the white blood corpuscles—after the manner of amoebæ, surround and attack and then devour (“phagocyte”) the germs which enter the body, thus rendering them harmless. He considered inoculation as a sort of preliminary training of these wandering white cells, so that if the disease against which the patient had been inoculated should befall him the “phagocytes” would be prepared and the more readily destroy the offending bacteria. When a person dies of an infectious disease, he explains it by claiming that the number of bacteria was too large for the wandering cells to overcome and devour. His theory has many opponents, who declare that diseases are cured by the cessation of the process of development of the bacteria in consequence of their death.

The practical medicine of the modern age has gained many important and permanent advantages through the improvements in diagnosis of the phenomena and pictures of disease. These aids to practical knowledge are derived from the natural sciences, which have been so wonderfully developed in modern days. The physical diagnosis of the present time took its origin in the eighteenth century, when Auenbrugger announced his method of percussion. Not long after that René Laennec presented his method of auscultation, a method of listening to the sounds produced in the chest when air is inspired and expired in health and disease, and also to the sound produced by the heart and its valves in health and disease. It was quite by accident that he came upon his great invention.

He says: "I was consulted by a young person who was laboring under the general symptoms of a diseased heart. In her case percussion and the application of the hand (what modern doctors call palpation) were of little service because of a considerable degree of stoutness. The other method, that namely of listening to the sound within the chest by the direct application of the ear to the chest wall, being rendered inadmissible by the age and sex of the patient, I happened to recollect a simple and well-known fact in acoustics and fancied it might be turned to some use on the present occasion. The fact I allude to is the great distinctness with which we hear the scratch of a pin at one end of a piece of wood on applying our ear to the other.

"Immediately on the occurrence of this idea I rolled a quire of paper into a kind of cylinder and applied one end of it to the region of the heart and the other to my ear. I was not a little surprised and pleased to find that I could thereby perceive the action of the heart in a manner much more clear and distinct than I had ever been able to do by the immediate application of the ear.

"From this moment I imagined that the circumstance might furnish means for enabling us to ascertain the character not only of the action of the heart, but of every species of sound produced by the motion of all the thoracic viscera, and consequently for the exploration of the respiration, the voice, the râles and perhaps even the fluctuation of fluid effused in the pleura or pericardium. With this conviction I forthwith commenced at the Necker Hospital a series of observations from which I have been able to deduce a set of new signs of the diseases of the chest. These are for the most part certain, simple and prominent, and calculated perhaps to render the diagnosis of the diseases of the lungs, heart and pleura as decided and circumstantial as the indications furnished to the surgeons by the finger or sound in the complaints wherein these are of use."

He worked out the practical and mechanical aspect, making a stethoscope about ten inches long with a diameter of four inches, and contained in its lower end an obturator, upon which he laid great stress. Laennec's interpretation of the sounds heard was based upon perfectly definite morbid conditions existing in the thoracic viscera, while Skoda formed his physical rules upon the basis of the principles of acoustics. Piorry improved the stethoscope and invented the pleximeter, an instrument used for the aid of mediate percussion. The percussion hammer was next invented, designed to take the place of the fingers for tapping.

One of the greatest inventions of all ages is that of the ophthalmoscope by Helmholtz. By means of this instrument the oculist can inspect the interior of the eye and easily decide whether it is in healthy or diseased condition. The laryngoscope is second in importance only to the ophthalmoscope. A few of the other diagnostic instruments that have since been in use are the aural and nasal specula, rectal and vaginal specula, the endoscope for examining the interior of the bladder and the spectroscope for the detection of sugar and blood-stains.

The laboratory for chemical and bacteriological examinations of excreta and secretions has since been of such aid in diagnosis that it is hard to appreciate the fact that the profession has had its benefit only for a few years past. The progress of physical diagnosis has been of incalculable benefit to humanity; the physician has been more accurate in finding the disease or its cause, and once having established this, has been able to treat the disease with more confidence and surety.

The progress of surgery in modern days has been described by Baas: "Surgery has always presented in its development a much pleasanter picture of steady progress than that offered by medicine proper, for its objects and

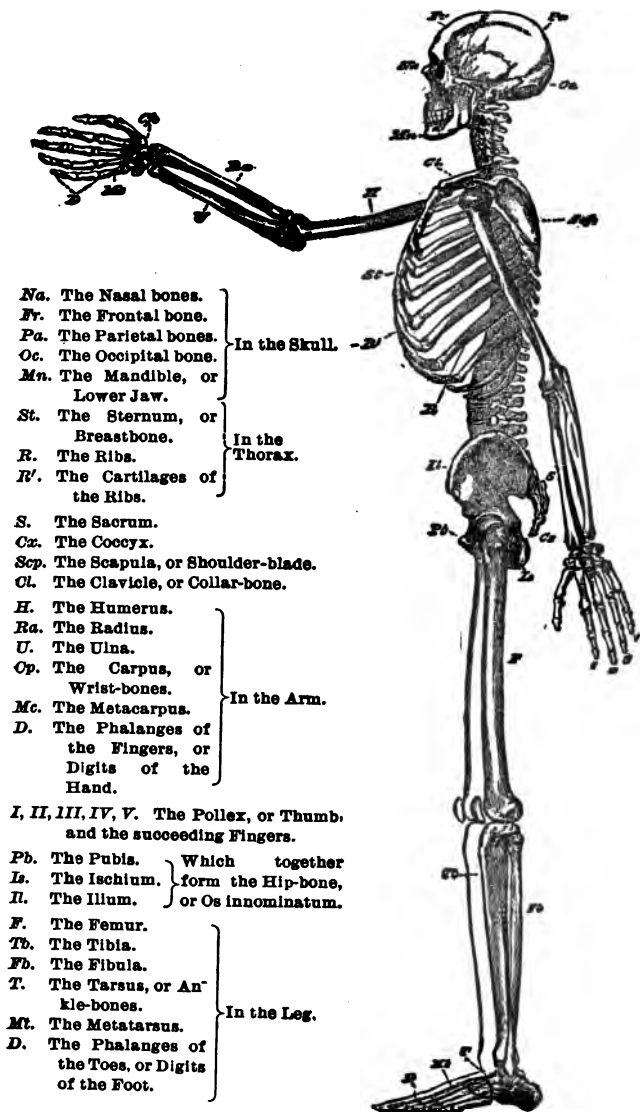


Fig. 10—HUMAN SKELETON IN PROFILE

its practice do not necessitate the illumination of dark paths by the torch of theory, which diffuses far more soot than light. Accordingly Chamisso calls surgery 'the seeing portion of the healing art.' Thus, too, the surgery of our century, in accordance with the character of the people who have shared in its development, but unaltered by the opinions of schools and their often varying methods, has striven vigorously and steadily after a perfection based upon the foundation of experience and for principles which the past, and particularly the eighteenth century, had taught. If the sixteenth century opened the way for the checking of hemorrhage and established this art in its scientific position, and if the seventeenth century accomplished the same results in the simplification and improvement of the art of dressing wounds; if too the eighteenth century gave a scientific elevation, so far as its means would permit, to both these methods, so in our own century surgery stands upon a scientific level with medicine proper, tho its objects are far more accessible, direct and comprehensible than those of the latter science and its position more favorable, so that its progress has been almost constant and uninterrupted.

"In full possession of the results of a normal surgical and topographical anatomy, almost perfect in its development (a position which admits of both boldness and certainty in treatment), it has likewise been able to utilize in an eminently practical way the acquisitions of pathological anatomy, applying them as well to diagnosis as to operative and therapeutic aims. Microscopic pathological anatomy in particular has become of extended importance in surgical knowledge and practice. By it, above all, our knowledge of secondary wound-diseases, of the fate of the secretions of wounds and their effects upon the organism, of the character of the different forms of tumors and their methods of growth and diffusion, etc., has been rendered clearer, and thus many fruitful facts and views have been contributed to surgical treatment.

"Above all the external conditions of the healing process have been observed more attentively than in the entire past, and consequently the after-treatment of wounds, both local and hygienic, has been brought more into the foreground. Above all, amputations, so frequent at an earlier date, have largely disappeared, and military surgery, as well as hospital and civil surgery, has inclined rather to the preservation of wounded parts and members than to their removal. Thus has grown up the scientific and rational, so-called conservative surgery of our century.

"A characteristic stamp has been impressed upon the surgery of our century by the bold and somewhat unexpectedly successful practice of visceral surgery, or the surgery of the cavities of the body, from the ligation of the great internal vessels to the extirpation of ovarian tumors, the spleen, kidneys, larynx, etc., a practice which contrasts strongly with that of earlier surgery, which was, on the whole, rather a surgery of the outer members, if such an expression is permissible."

Also should be mentioned the improvement in plastic operations, among which should be counted the operation of osteoplasty, introduced by B. Langenbeck in 1859. The operations mentioned and other operative methods, some of them tedious and difficult, were certainly greatly facilitated, in fact almost conditioned, by the discovery of the anesthetic effects of ether and chloroform, one of the most beneficent discoveries ever made. The rapid operations of an earlier date now disappeared, and instead of rapidity of method, the security of the patient and the certainty of success were now demanded. Pain was no longer the occasion for an avoidance of more tedious, but safer methods of procedure. Another advance in surgery, not so beneficent, however, in its results, was the rubber bandage of Esmarch, introduced in 1873 for the production of artificial anemia.

The use of animal fibers for sutures was suggested first by Sir Astley Cooper. In 1852 plaster bandages were used

first and have been constantly employed since then for fractures.

The discovery of anesthesia by Dr. William T. G. Morton in 1846 was one of the greatest boons to mankind that the history of the world records. For many centuries and in many climes there had been constant search for the abolishment of pain during operations. The Chinese have been able, or made claims to that effect, to produce anesthesia by means of a preparation they call Mago. Herodotus says that the Scythians were accustomed to intoxicate themselves by the inhalation of the fumes of hemp-seed. Pliny tells of the anesthetic qualities of the mandragora and its use preparatory to surgical operations. Opium and hyoscyamus were used in the Middle Ages, and this was continued down to the time of Morton's discovery of pure sulphuric ether as a perfect narcotic and anesthetic. He was a dentist and experimented on himself in Boston. His description follows: "I shut myself up in my room, seated myself in the operating chair and commenced inhaling. It partially suffocated me, but produced no decided effect. I then saturated my handkerchief and inhaled it from that. I looked at my watch and soon lost consciousness. As I recovered, I felt a numbness in my limbs with a sensation like a nightmare and would have given the world for some one to come and arouse me. I thought for a moment I should die. At length I felt a slight tingling of the blood in the end of my third finger and made an effort to touch it with my thumb, but without success. At a second effort I touched it, but there seemed to be no sensation. I pinched my thigh, but sensation was imperfect. I immediately looked at my watch. I had been insensible between seven and eight minutes."

Shortly after Morton's discovery of ether, which was not fully appreciated at the time except in Boston, Professor Simpson, of Edinburgh, introduced chloroform to be used for destroying pains in obstetrics.

To Lord Lister, of England, is due the introduction of the antiseptic method in the surgical treatment of wounds,

from which was later developed the aseptic technique now employed in every hospital and in all surgical operations. In the *Lancet* for March 16, 1867, Lister published the first of a series of articles entitled "On a New Method of Treating Compound Fracture, Abscess, etc., with Observation on the Condition of Suppuration." In the first article of this series the following statements appear:

"Turning now to the question how the atmosphere produces decomposition of organic substances, we find that a flood of light has been thrown upon this most important subject by the philosophic researches of M. Pasteur, who has demonstrated by thoroly convincing evidence that it is not to its oxygen or to any of its gaseous constituents that the air owes this property, but to minute particles suspended in it, which are the germs of various low forms of life, long since revealed by the microscope and regarded as merely accidental concomitants of putrescence, but now shown by Pasteur to be its essential cause, resolving the complex organic compounds into substances of simpler chemical constitution, just as the yeast plant converts sugar into alcohol and carbonic acid.

"Applying these principles to the treatment of compound fracture, bearing in mind that it is from the vitality of the atmospheric particles that all the mischief arises, it appears that all that is requisite is to dress the wound with some material capable of killing these septic germs, provided that any substance can be found reliable for this purpose, yet not too potent as a caustic.

"My attention having for several years been directed to the subject of suppuration, more especially in its relation to decomposition, I saw that such a powerful antiseptic was peculiarly adapted for experiments with a view to elucidating that subject, and while I was engaged in the investigation the applicability of carbolic acid for the treatment of compound fracture naturally occurred to me.

"My first attempt of this kind was made in Glasgow Royal Infirmary in March, 1865, in a case of compound fracture of the leg. It proved unsuccessful, in conse-

quence, as I now believe, of improper management; but subsequent trials have more than realized my most sanguine anticipations.

"Further, I have found that when the antiseptic treatment is efficiently conducted, ligatures may be safely cut short and left to be disposed of by absorption or otherwise. Should this particular branch of the subject yield all that it promises, should it turn out on further trial that when the knot is applied on the antiseptic principle, we may calculate as securely as if it were absent on the occurrence of healing without any deep-seated suppuration, the deligation of main arteries in their continuity will be deprived of the two dangers that now attend it, viz., those of secondary hemorrhage and an unhealthy state of the wound. Further, it seems not unlikely that the present objection to tying an artery in the immediate vicinity of a large branch may be done away with, and that even the innominate, which has lately been the subject of an ingenious experiment by one of the Dublin surgeons, on account of its well-known fatality under the ligature for secondary hemorrhage, may cease to have this unhappy character when the tissues in the vicinity of the thread, instead of becoming softened through the influence of an irritating decomposing substance, are left at liberty to consolidate firmly near an unoffending tho foreign body.

"There is, however, one point more that I cannot but advert to, viz., the influence of this mode of treatment upon the general healthiness of a hospital. Previously to its introduction the two large wards in which most of my cases of accident and of operation are treated were among the unhealthiest in the whole surgical division of the Glasgow Royal Infirmary, in consequence apparently of those wards being unfavorably placed with reference to the supply of fresh air, and I have felt ashamed when recording the results of my practice to have so often to allude to hospital gangrene or pyemia. It was interesting,

though melancholy, to observe that whenever all or nearly all the beds contained cases with open sores, these grievous complications were pretty sure to show themselves; so that I came to welcome simple fractures, though in themselves of little interest either for myself or the students, because their presence diminished the proportion of open sores among the patients. But since the antiseptic treatment has been brought into full operation, and wounds and abscesses no longer poison the atmosphere with putrid exhalations, my wards, tho in other respects under precisely the same circumstances as before, have completely changed their character; so that during the last nine months not a single instance of pyemia, hospital gangrene or erysipelas has occurred in them. As there appears to be no doubt regarding the cause of this change, the importance of the fact can hardly be exaggerated."

Modern therapeutics has emerged, or more properly, has almost entirely emerged, from the great obscurity and uncertainty in which it was formerly enveloped. This applies to the medical profession and not to the mass of people, the laity. The former have completely revised their materia medica, making it much more simple than it has ever been before.

A form of therapeutics which has lately been given much attention and which is based upon Metchnikoff's theories is that of serum-therapy. Hydrophobia, diphtheria and tetanus are examples of the successful application of these researches. The protective antitoxines, taken from the serum of the lower animals, when injected early enough into the diseased man, supply new strength or protection, without which the patient would surely die. The dreaded consumption and cerebro-spinal meningitis are being studied and experimented upon now, the latter already with a considerable degree of success.

CHAPTER XI

MODERN PHYSIOLOGY.

THE views concerning the working of the human body and its structure, while very complete, are not positive even in the present day. To understand the functions of the several parts of the human mechanism, it is absolutely essential that one should be acquainted with the structure of all its parts, even to the smallest details, so that in reviewing the modern physiological beliefs one also sees modern anatomy. Thomas Huxley in his famous work on physiology has summed up the workings and structure of the human organism and the following description is based upon his statements, these having been brought up to the latest word in physiological and anatomical research.

"The body of a living man," he says, "performs a great diversity of actions, some of which are obvious; others require more or less careful observation, and yet others can be detected only by the employment of the most delicate appliances of science. Thus some part of the body of a living man is plainly always in motion. Even in sleep, when the limbs, head and eyelids may be still, the incessant rise and fall of the chest continue to show that slumber is proceeding and not death.

"More careful observation, however, is needed to detect the motion of the heart, or the pulsation of the arteries, or the changes in the size of the pupil of the eye with varying light, or to ascertain that the air which is breathed

out of the body is hotter and damper than the air which is taken in by breathing. And, lastly, when an effort is made to ascertain what happens in the eye when that organ is adjusted to different distances, or what in a nerve when it is excited, or of what materials flesh and blood are made, or in virtue of what mechanism it is that a sudden pain makes one start, there is need to call into operation all the methods of inductive and deductive logic, all the resources of physics and chemistry and all the delicacies of the art of experiment. The sum of the facts and generalizations at which we arrive by these various modes of inquiry, be they simple or be they refined, concerning the actions of the body and the manner in which those actions are brought about, constitutes the science of Human Physiology.

“Suppose a chamber with walls of ice, through which a current of pure ice-cold air passes; the walls of the chamber will, of course, remain unmelted. Now, having weighed a healthy living man with great care, let him walk up and down the chamber for an hour. In doing this he will obviously do a considerable amount of work and use up a proportionate quantity of energy, as much, at least, as would be required to lift his weight as high and as often as he has raised himself at every step. But, in addition, a certain quantity of the ice will be melted or converted into water, showing that the man has given off heat in abundance. Furthermore, if the air which enters the chamber be made to pass through lime-water, it will cause no cloudy white precipitate of carbonate of lime, because the quantity of carbonic acid in ordinary air is so small as to be inappreciable in this way. But if the air which passes out is made to take the same course, the lime-water will soon become milky from the precipitation of carbonate of lime, showing the presence of carbonic acid, which, like the heat, is given off by the man.

“Again, even if the air be quite dry as it enters the chamber (and the chamber be lined with some material so as to

shut out all vapor from the melting ice walls), that which is breathed out of the man and that which is given off from his skin will exhibit clouds of vapor, which vapor, therefore, is derived from the body. After the expiration of the hour during which the experiment has lasted, let the man be released and weighed once more. He will be found to have lost weight. Thus a living, active man constantly does mechanical work, gives off heat, evolves carbonic acid and water and undergoes a loss of substance."

Plainly this state of things could not continue for an unlimited period or the man would dwindle to nothing. But long before the effects of this gradual diminution of substance become apparent to a bystander, they are felt by the subject of the experiment in the form of the two imperious sensations called hunger and thirst. To still these cravings, to restore the weight of the body to its former amount, to enable it to continue giving out heat, water and carbonic acid at the same rate for an indefinite period it is absolutely necessary that the body should be supplied with each of three things and with three only. These are, first, fresh air; secondly, drink—consisting of water in some shape or other, however much it may be adulterated; thirdly, food. That compound known to chemists as proteid matter and which contains carbon, hydrogen, oxygen and nitrogen, must form a part of this food if it is to sustain life indefinitely, and fatty, starchy or saccharine—*i.e.*, carbohydrate matters—together with a certain amount of salts, ought to be contained in the food if it is to sustain life conveniently.

A certain proportion of the matter taken in as food either cannot be, or at any rate is not used, and leaves the body as excrementitious matter, having simply passed through the alimentary canal without undergoing much change and without ever being incorporated into the actual substance of the body. But, under healthy conditions, and when only so much as is necessary is taken, no important proportion of either proteid matter, or fat, or starchy or

saccharine food passes out of the body as such. Almost all real food ultimately leaves the body as waste in the form either of water, or of carbonic acid, or of a third substance called urea, or of certain saline compounds or salts.

Chemists have determined that these products, which are thrown out of the body and are called excretions, contain, if taken together, far more oxygen than the food and water taken into the body. Now, the only possible source whence the body can obtain oxygen, except from food and water, is the air which surrounds it. And careful investigation of the air which leaves the chamber in the imaginary experiment described above would show not only that it has gained carbonic acid from the man, but that it has lost oxygen in equal or rather greater amount to him.

Thus, if a man is neither gaining nor losing weight, the sum of the weights of all the substances above enumerated which leave the body ought to be exactly equal to the weight of the food and water which enter it, together with that of the oxygen which it absorbs from the air. And this is proved to be the case.

Hence it follows that a man in health and "neither gaining nor losing flesh" is incessantly oxidating and wasting away and periodically making good the loss. So that if, in his average condition, he could be confined in the scale-pan of a delicate spring balance, like that used for weighing letters, the scale-pan would descend at every meal and ascend in the intervals, oscillating to equal distances on each side of the average position, which would never be maintained for longer than a few minutes. There is, therefore, no such thing as a stationary condition of the weight of the body, and what we call such is simply a condition of variation within narrow limits—a condition in which the gains and losses of the numerous daily transactions of the economy balance one another.

Suppose this diurnally balanced physiological state to

be reached, it can be maintained only so long as the quantity of the mechanical work done and of heat or other force evolved remains absolutely unchanged.

Let such a physiologically balanced man lift a heavy body from the ground and the loss of weight which he would have undergone without that exertion will be increased by a definite amount, which cannot be made good unless a proportionate amount of extra food be supplied to him. Let the temperature of the surrounding air fall, and the same result will occur if his body remains as warm as before.

On the other hand, diminish his exertion and lower his production of heat, and either he will gain weight or some of his food will remain unused.

Thus, in a properly nourished man, a stream of food is constantly entering the body in the shape of complex compounds containing comparatively little oxygen, as constantly the elements of the food (whether before or after they have formed part of the living substance) are leaving the body combined with more oxygen. And the incessant breaking down and oxidation of the complex compounds which enter the body are definitely proportioned to the amount of energy the body gives out, whether in the shape of heat or otherwise, just in the same way as the amount of work to be got out of a steam engine and the amount of heat it and its furnace give off bear a strict proportion to its consumption of fuel.

The condition to which the name of fever is given is characterized essentially by the temperature of the body being higher than is usual in health. Thus it may rise to as much as 41° C. (105.8° F.) or occasionally even above this point, and there has been much dispute as to how high temperature arises. A common cause is a disturbance of the mechanism by which heat is lost to the body, some diminution in loss of heat leading naturally to a rise of temperature. On the other hand, direct measurement shows that a fevered person often gives off more heat

than usual and at the same time uses up more oxygen and produces more carbonic acid and urea than usual. In such cases there is no doubt that the abnormally high temperature is largely due to an over-production of heat.

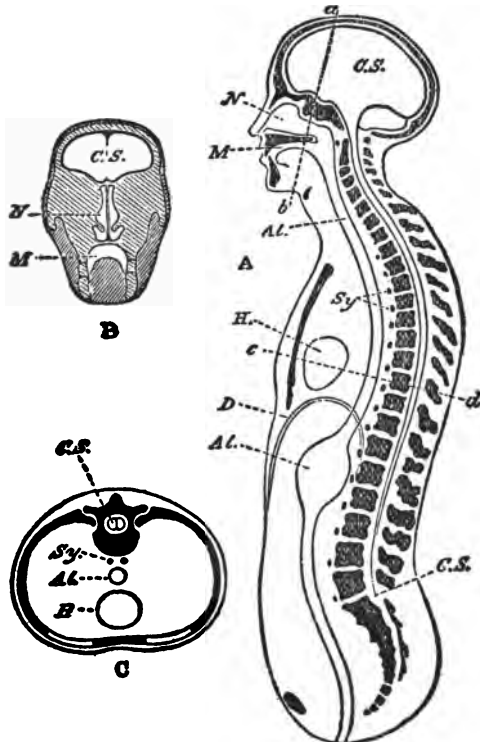


Fig. 11—DIAGRAMMATIC SECTION OF BODY

Viewed vertically through the medium plane. *CS*, the cerebrospinal nervous system; *N*, the cavity of the nose; *M*, that of the mouth; *Al.*, *Al.*, the alimentary canal represented as a simple tube; *H*, the heart; *D*, the diaphragm; *Sy.*, the sympathetic ganglia.

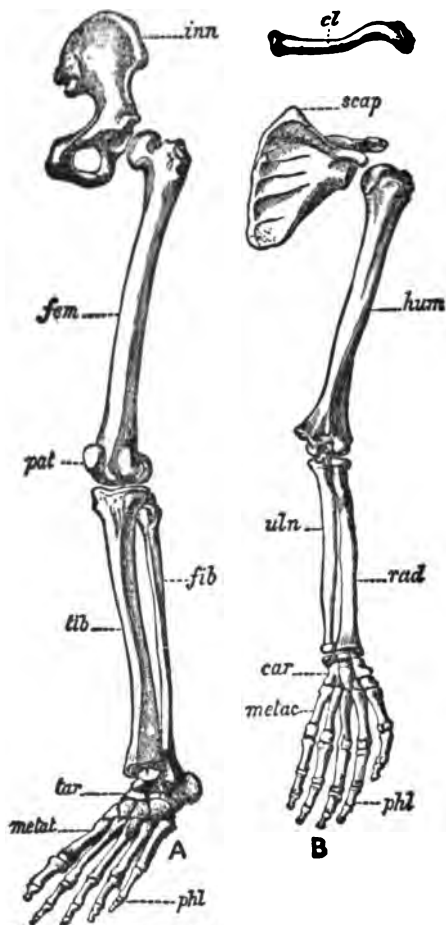


Fig. 12—BONES OF LIMBS. LEFT FRONT VIEW

A, the innominate and bones of the leg; inn, innominate or hip-bone; fem, femur; pat, patella or knee-cap; tib, tibia; fib, fibula; tar, (seven) tarsal bones; metat, (five) metatarsal bones; phl, (fourteen) phalanges; **B**, the scapula, clavicle, and bones of the arm; cl, clavicle or collar-bone; scap, scapula or shoulder-bone; hum, humerus; rad, radius; uln, ulna; car, (eight) carpal bones; metac, (five) metacarpal bones; phl, (fourteen) phalanges.

From these general considerations regarding the nature of life, considered as physiological work, one may turn for the purpose of taking a like broad survey of the apparatus which does the work.

The human body is obviously separable into head, trunk and limbs. In the head, the brain-case or skull is distinguishable from the face. The trunk is naturally divided into the chest or thorax and the belly or abdomen. Of the limbs there are two pairs—the upper, or arms, and the lower, or legs, and legs and arms again are subdivided by their joints into parts which obviously exhibit a rough correspondence—thigh and upper arm, leg and forearm, ankle and wrist, toes and fingers, plainly answering to one another. And the two last, in fact, are so similar that they receive the same name of digits, while the several joints of the fingers and toes have the common denomination of phalanges.

The whole body thus composed (without the viscera or organs which fill the cavities of the trunk) is seen to be bilaterally symmetrical; that is to say, if it were split lengthwise by a great knife, which should be made to pass along the middle line of both the dorsal and ventral (or back and front) aspects, the two halves would almost exactly resemble one another.

One-half of the body, divided in the manner described, would exhibit in the trunk the cut faces of thirty-three bones, joined together by a very strong and tough substance into a long column, which lies much nearer the dorsal (or back) than the ventral (or front) aspect of the body. The bones thus cut through are called the bodies of the vertebræ. They separate a long, narrow canal called the spinal canal, which is placed upon their dorsal side, from the spacious chamber of the chest and abdomen, which lies upon their ventral side. There is no direct communication between the dorsal canal and the ventral cavity.

The spinal canal contains a long white cord—the spinal

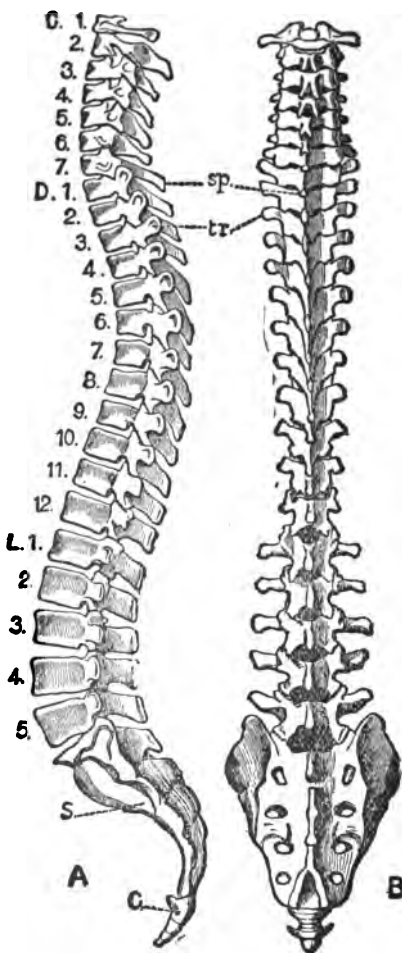


Fig. 13—VERTEBRAL COLUMN

A, side view, left side; B, back view; C, 1-7, cervical vertebrae; D, 1-12, dorsal (thoracic) vertebrae; L, 1-5, lumbar vertebrae; S, sacrum; C, coccyx; sp, spinous processes; tr, transverse processes—(Huxley).

cord—which is an important part of the nervous system. The ventral chamber is divided into the two subordinate cavities of the thorax and abdomen by a remarkable, partly fleshy and partly membranous partition, the diaphragm, which is concave toward the abdomen and convex toward the thorax. The alimentary canal traverses these cavities from one end to the other, piercing the diaphragm. So does a long double series of distinct masses of nervous substance, which are called ganglia. These are connected together by nervous cords and constitute the so-called sympathetic system. The abdomen contains, in addition to these parts, the two kidneys, one placed against each side of the vertebral column and connected each by a tube, the ureter, to a muscular bag, the bladder, lying at the bottom of the abdomen; the liver, the pancreas or “sweetbread,” and the spleen. The thorax encloses, besides its segment of the alimentary canal and of the sympathetic system, the heart and the two lungs. The latter are placed one on each side of the heart, which lies nearly in the middle of the thorax.

Where the body is succeeded by the head the uppermost of the thirty-three vertebral bodies is followed by a continuous mass of bone, which extends through the whole length of the head, and, like the spinal column, separates a dorsal chamber from a ventral one. The dorsal chamber, or cavity of the skull, opens into the spinal canal. It contains a mass of nervous matter called the brain, which is continuous with the spinal cord, the brain and the spinal cord together constituting what is termed the cerebro-spinal system. The ventral chamber, or cavity of the face, is almost entirely occupied by the mouth and pharynx, into which last the upper end of the alimentary canal (called gullet or oesophagus) opens.

Thus the study of a longitudinal section shows that the human body is a double tube, the two tubes being completely separated by the spinal column and the bony axis of the skull, which form the floor of the one tube and the

roof of the other. The dorsal tube contains the cerebro-spinal axis; the ventral tube contains the alimentary canal, the sympathetic nervous system, the heart and the lungs, besides other organs.

Transverse sections taken perpendicularly to the axis of the vertebral column or to that of the skull show still more clearly that this is the fundamental structure of the human body and that the great apparent difference between the head and the trunk is due to the different size of the dorsal cavity relatively to the ventral. In the head the former cavity is very large in proportion to the size of the latter; in the thorax or abdomen it is very small.

The limbs contain no such chambers as are found in the body and the head, but with the exception of certain branching tubes filled with fluid, which are called blood-vessels and lymphatics, are solid or semi-solid throughout.

Such being the general character and arrangement of the parts of the human body, it will next be well to consider into what constituents it may be separated by the aid of no better means of discrimination than the eye and the anatomist's knife.

With no more elaborate aids than these, it becomes easy to separate that tough membrane which invests the whole body and is called the skin, or integument, from the parts which lie beneath it. Furthermore, it is readily enough ascertained that this integument consists of two portions: a superficial layer, which is constantly being shed in the form of powder or scales, composed of minute particles of horny matter, and is called the epidermis, and the deeper part, the dermis, which is dense and fibrous. The epidermis, if wounded, neither gives rise to pain nor bleeds. The dermis, under like circumstances, is very tender and bleeds freely. A practical distinction is drawn between the two in shaving, in the course of which operation the razor ought to cut only epidermal structures, for if it go a shade deeper it gives rise to pain and bleeding.

The skin can be readily enough removed from all parts

of the exterior, but at the margins of the apertures of the body it seems to stop, and to be replaced by a layer which is much redder, more sensitive, bleeds more readily and which keeps itself continually moist by giving out a more or less tenacious fluid called mucus. Hence at these apertures the skin is said to stop and to be replaced by mucous membrane, which lines all those interior cavities, such as the alimentary canal, into which the apertures open. But, in truth, the skin does not really come to an end at these points, but is directly continued into the mucous membrane, which last is simply an integument of greater delicacy, but consisting fundamentally of the same two layers—a deep, fibrous layer, called also dermis, and containing blood-vessels, and a superficial, bloodless one, now called the epithelium. Thus every part of the body might be said to be contained between the walls of a double bag, formed by the epidermis, which invests the outside of the body, and the epithelium, its continuation, which lines the alimentary canal.

The dermis of the skin and that of the mucous membranes are chiefly made up of a filamentous substance, which yields abundant gelatine on being boiled and is the matter which tans when hide is made into leather. This is called connective tissue, because it is the great connecting medium by which the different parts of the body are held together. Thus it passes from the dermis between all the other organs, ensheathing the muscles, coating the bones and cartilages and eventually reaching and entering into the mucous membranes. And so completely and thoroly does the connective tissue permeate almost all parts of the body that if every other tissue could be dissected away a complete model of all the organs would be left composed of this tissue. Connective tissue varies very much in character; in some places being very soft and tender, at others—as in the tendons and ligaments, which are almost wholly composed of it—attaining great strength and density.

Among the most important of the tissues embedded in and ensheathed by the connective tissue are some the presence and action of which can be readily determined during life.

If the upper arm of a man whose arm is stretched out be tightly grasped by another person, the latter, as the former bends up his forearm, will feel a great soft mass, which lies at the fore part of the upper arm, swell, harden and become prominent. As the arm is extended again the swelling and hardness vanish.

On removing the skin, the body which thus changes its configuration is found to be a mass of red flesh, sheathed in connective tissue. The sheath is continued at each end into a tendon, by which the muscle is attached, on the one hand, to the shoulder-bone and on the other to one of the bones of the forearm. This mass of flesh is the muscle called biceps, and it has the peculiar property of changing its dimensions—shortening and becoming thick in proportion to its decrease in length—when influenced by the will as well as by some other causes, called stimuli, and of returning to its original form when let alone. This temporary change in the dimensions of a muscle, this shortening and thickening, is spoken of as its contraction. It is by reason of this property that muscular tissue becomes the great motor agent of the body; the muscles being so disposed between the system of levers which support the body that their contraction necessitates the motion of one lever upon another.

These levers form part of the system of hard tissues which constitute the skeleton. The less hard of these are the cartilage, composed of a dense, firm substance, ordinarily known as "gristle." The latter are the bones, which are masses of tissue, hardened by being impregnated with phosphate and carbonate of lime. They are animal tissues which have become, in a manner, naturally petrified; and when the salts of lime are extracted, as they may be by

the action of acids, a model of the bone in soft and flexible animal matter remains.

More than 200 separate bones are ordinarily reckoned in the human body, though the actual number of distinct bones varies at different periods of life, many bones which are separate in youth becoming united together in old age. Thus there are originally, as we have seen, thirty-three separate bodies of vertebræ in the spinal column, and the

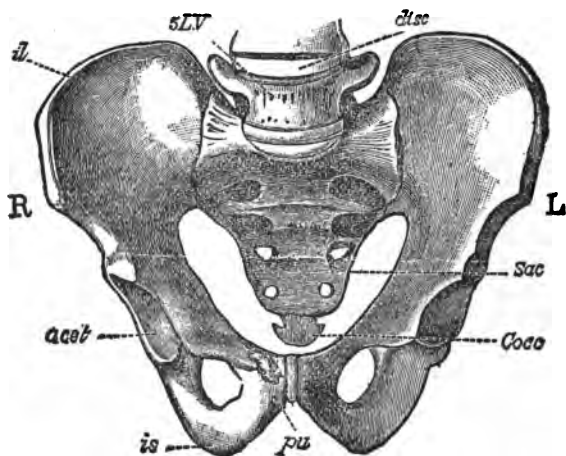


Fig. 14—PELVIS

Sac, sacrum; Cocc, coccyx; il, is, pu, ilium, ischium, pubis, three parts of the innominate or hip-bone; acet, acetabulum or cup for head of femur; 5LV, 5th lumbar vertebra; disc, disc of cartilage between vertebræ; R, right; L, left—(Huxley).

upper twenty-four of these commonly remain distinct throughout life. But the twenty-fifth, twenty-sixth, twenty-seventh, twenty-eighth and twenty-ninth early unite into one great bone, called the sacrum, and the four remaining vertebræ often run into one bony mass called the coccyx.

In early adult life the skull contains twenty-two natu-

rally separate bones, but in youth the number is much greater and in old age far less.

Twenty-four ribs bound the chest laterally, twelve on each side, and most of them are connected by cartilages with the breast-bone or sternum. In the girdle which supports the shoulder two bones are always distinguishable as the scapula, or shoulder-blade, and the clavicle, or collar-bone. The pelvis, to which the legs are attached, consists of two separate bones called the ossa innominata, or hip-bones, in the adult; but each os innominatum is separable into three (called pubis, ischium and ilium) in the young.

There are thirty bones in each of the arms and the same number in each of the legs, counting the patella, or kneecap.

All these bones are fastened together by ligaments, or by cartilages, and where they play freely over one another a coat of cartilage furnishes the surfaces which come into contact. The cartilages which thus form part of a joint are called articular cartilages and their free surfaces, by which they rub against each other, are lined by a delicate synovial membrane, which secretes a lubricating fluid—the synovia.

Tho the bones of the skeleton are all strongly enough connected together by ligaments and cartilages, the joints play so freely and the center of gravity of the body, when erect, is so high up, that it is impossible to make a skeleton or a dead body support itself in the upright position. That position, easy as it seems, is the result of the contraction of a multitude of muscles which oppose and balance one another. Thus the foot affording the surface of support, the muscles of the calf must contract or the legs and body would fall forward. But this action tends to bend the legs, and to neutralize this and keep the leg straight, the great muscles in front of the thigh must come into play. But these, by the same action, tend to bend the body forward on the legs, and if the body is to be kept straight, they

must be neutralized by the action of the muscles of the buttocks and of the back.

The erect position, then, which we assume so easily and without thinking about it, is the result of the combined and accurately proportioned action of a vast number of muscles. What is it that makes them work together in this way?

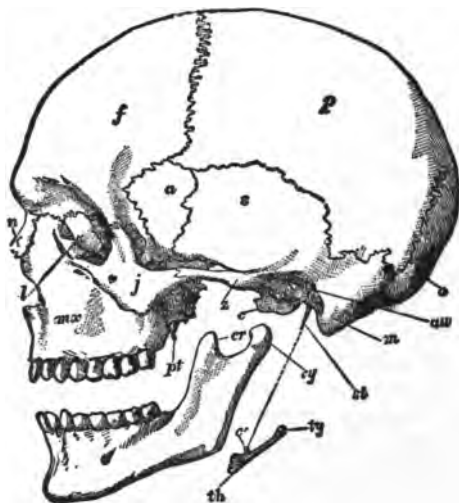


Fig. 15—SIDE VIEW OF SKULL

f, Frontal bone; p, parietal; o, occipital; a, wing of sphenoid; s, flat part of temporal; c, m, st, other parts of temporal; au, opening of ear or external auditory canal; z, process of temporal passing to j, the cheek-bone; mx, the upper jaw bone; n, nasal bone; l, lachrymal; pt, part of sphenoid. The lower jaw bone is drawn downward: cy, its process which articulates with the temporal; cr, its process to which muscles of mastication are attached; th, ty, hyoid bone, the dotted line indicating its attachment by a ligament to the temporal—(Huxley).

Let any person in the erect position receive a violent blow on the head, and the effect is rapid. On the

instant he drops prostrate, in a heap, with his limbs relaxed and powerless. What has happened to him? The blow may have been so inflicted as not to touch a single muscle of the body; it may not cause the loss of a drop of blood; and, indeed, if the "concussion," as it is called, has not been too severe, the sufferer, after a few moments of unconsciousness, will come to himself and be as well as ever again. Clearly, therefore, no permanent injury has been done to any part of the body, least of all to the muscles, but an influence has been exerted upon a something which governs the muscles. And a similar influence may be the effect of very subtle causes. A strong mental emotion, and even a very bad smell, will, in some people, produce the same effect as a blow.

These observations might lead to the conclusion that it is the mind which directly governs the muscles, but a little further inquiry will show that such is not the case. For people have been so stabbed or shot in the back as to cut the spinal cord without any considerable injury to other parts, and then they have lost the power of standing upright as much as before, tho their minds may have remained perfectly clear. And not only have they lost the power of standing upright under these circumstances, but they no longer retain any power of either feeling what is going on in their legs, or, by an act of their own will, causing motion in them.

And yet, tho the mind is thus cut off from the lower limbs, a controlling and governing power over them still remains in the body. For if the soles of the disabled feet be tickled, though the mind does not feel the tickling, the legs will be jerked up, just as would be the case in an uninjured person. Again, if a series of galvanic shocks be sent into the spinal cord, the legs will perform movements even more powerful than those which the will could produce in an uninjured person. And, finally, if the injury is of such a nature as not simply to divide or injure the spinal cord in one place only, but to crush or pro-

foundly disorganize it, all these phenomena cease; tickling the soles, or sending galvanic shocks along the spine, will produce no effect upon the legs.

By examinations of this kind carried still further, the remarkable result is reached that, while the brain is the seat of all sensation and mental action and the primary source of all voluntary muscular contractions, the spinal cord is by itself capable of receiving an impression from the exterior and converting it, not only into a simple muscular contraction, but into a combination of such actions.

Thus, in general terms, it may be said of the cerebro-spinal nervous centers, that they have the power, when they receive certain impressions from without, of giving rise to simple or combined muscular contractions.

But these impressions from without are of very different characters. Any part of the surface of the body may be so affected as to give rise to the sensations of contact or of heat or cold, and any or every substance is able, under certain circumstances, to produce these sensations. But only very few and comparatively small portions of the bodily framework are competent to be affected in such a manner as to cause the sensations of taste or of smell, of sight or of hearing, and only a few substances or particular kinds of vibrations are able so to affect those regions. These very limited parts of the body, which induce relation with particular kinds of substances or forms of force, are what are termed sensory organs. There are two such organs for sight, two for hearing, two for smell and one, or more strictly speaking two, for taste.

With this brief view of the structure of the body, of the organs which support it, of the organs which move it and of the organs which put it in relation with the surrounding world, or, in other words, enable it to move in harmony with influences from without, next must be considered the means by which all this wonderful apparatus is kept in working order.

All work implies waste. The work of the nervous sys-

tem and that of the muscles, therefore, implies consumption either of their own substance or of something else. And as the organism can make nothing, it must possess the means of obtaining from without that which it wants, and of throwing off from itself that which it wastes; and we

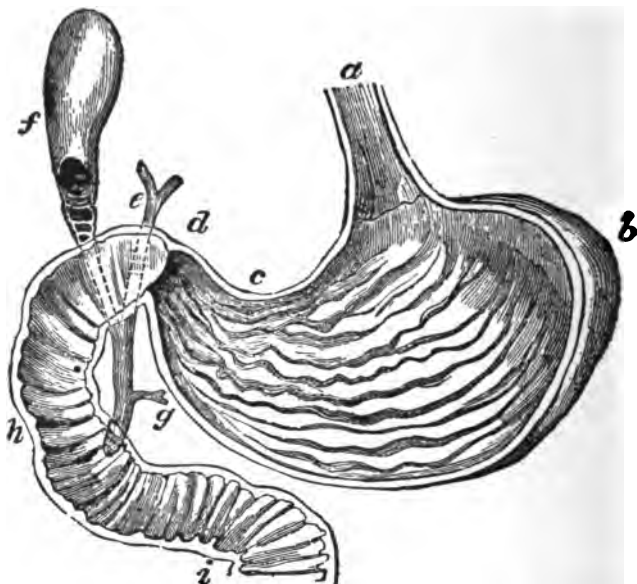


Fig. 16—SECTION OF STOMACH

a, Oesophagus; b, cardiac dilatation; c, lesser curvature; d, pylorus; e, biliary duct; f, gall-bladder; g, pancreatic duct opening in common with the cystic duct opposite h; h, i, duodenum—(Huxley).

have seen that, in the gross, it does these things. The body feeds, and it excretes. Now passing from the broad fact to the mechanism by which the fact is brought about, it is seen that the organs which convert food into nutriment are the organs of alimentation; those which dis-

tribute nutriment all over the body are organs of circulation; those which get rid of the waste products are organs of excretion.

The circulatory organs consist of a system of minute tubes, with very thin walls, termed capillaries, which are distributed through the whole organism except the epidermis and its products, the epithelium, the cartilages and the substance of the teeth. On all sides, these tubes pass into others, which are called arteries and veins; while these, becoming larger and larger, at length open into the heart, an organ which, as has been seen, is placed in the thorax. During life, these tubes and the chambers of the heart, with which they are connected, are all full of liquid, which is, for the most part, that red fluid with which all are familiar as blood.

A simple statement of the circulatory system, made recently by Albert M. Polon, runs as follows: "There are two sets of tubes connected with the heart, viz., arteries and veins, in which are valves permitting the flow of the blood in one direction only. The terminations of the arteries are connected with the veins by means of minute vessels, called capillaries. The principle upon which the blood is caused to circulate in these tubes is well represented by a hollow closed ring, with an enlargement at one point (corresponding to the heart), in which there is a valve opening only one way. It is clear that if such a ring be filled with water and placed upon the table there will be no movement in the tube, but if pressure be applied, the water within the tube will flow in the direction of least pressure and toward the point where the valve opens. Just as the difference of pressure thus is the causative factor of the flow in this ring, so in the heart, arteries, capillaries and veins the contraction of the heart-muscle performs the same office. The heart contracting propels the blood into the arteries. From these the blood passes into the capillaries, where the pressure is lower, and thence it

proceeds into the veins, where the pressure is still lower, until it finally reaches the heart.

"To appreciate clearly the working of the circulatory system, it is necessary briefly to consider the anatomy of

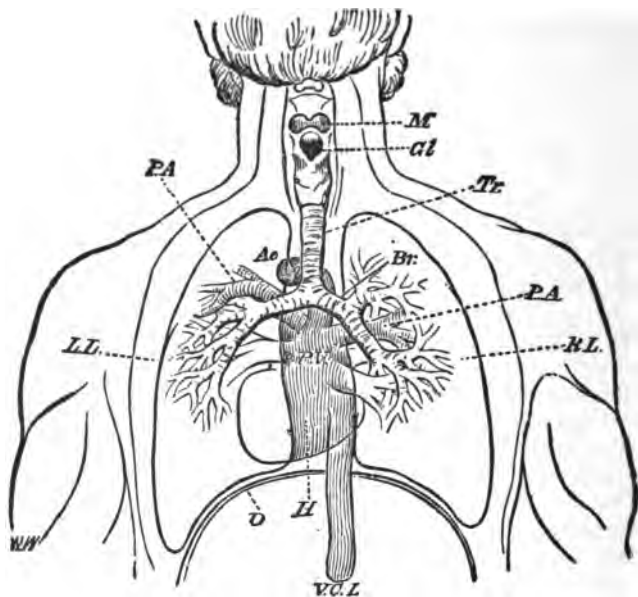


Fig. 17—NECK AND THORAX

Viewed from the back with vertebral column and posterior chest wall removed.

M, mouth; Gl, glottis; Tr, trachea; LL, left lung; RL, right lung; Br, bronchus; PA, pulmonary artery; PV, pulmonary vein; Ao, aorta; D, diaphragm; H, heart; VCI, vena cava inferior.

the heart. The heart is a hollow muscular organ, the cavity of which is separated into right and left halves by a longitudinal section, and each half is divided into an upper

receiving chamber, the 'auricle,' and the lower ejecting chamber, the 'ventricle.' But each ventricle is not completely separated from the corresponding auricle; the two communicate by means of an opening, called the 'auricular ventricular aperture,' which is provided with a valve, allowing the passage of blood from the auricle to the ventricle, but effectually preventing its return.

"Let a given quantity of blood be traced through this system, starting with one of the larger arteries. As said before, the blood will pass into the smaller arteries, thence into the 'arterioles' and finally into the capillaries. From here it is drained into 'venules,' which grow larger and larger to become veins and terminate at the upper half of the right side of the heart, viz., the right auricle. From the right auricle the blood is sent along into the right ventricle. This in its turn ejects it into the pulmonary arteries, which carry blood to the lungs. From the lungs the blood returns by the pulmonary veins to the left auricle, from where it enters into the left ventricle, to be finally ejected into the arteries. Thus the circulation of the blood has two phases: (1) When the blood is ejected from the right ventricle into the lungs and back into the left ventricle, and (2) when the blood ejected from the left ventricle passes through the system and is returned to the right side of the heart. This first phase is known as 'pulmonary' and the second as 'systemic.'"

The organs of alimentation are the mouth, pharynx, gullet, stomach and intestines, with their appendages, the pancreas and the liver. What they do is, first, to receive and grind the food. They then act upon it with chemical agents, of which they possess a store which is renewed as fast as it is used; and in this way convert the food by processes of digestion into a fluid containing nutritious matters in solution or suspension, and innutritious dregs or feces.

Now the fluid containing the dissolved or suspended nutritive matters which are the result of the process of

digestion, traverses the very thin layer of soft and permeable tissue which separates the cavity of the alimentary canal from the cavities of the innumerable capillary vessels which lie in the walls of that canal, and so enters the blood, with which those capillaries are filled. Whirled away by the torrent of the circulation, the blood, thus charged with nutritive matter, enters the heart, and is

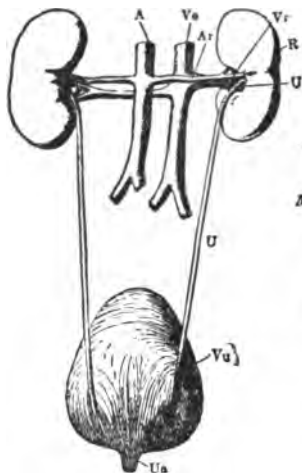


Fig. 18—URINARY ORGANS
 R, right kidney; U, ureter;
 Vu, bladder; Ua, urethra;
 A, aorta; Ar, right renal
 artery; Ve, inferior vena
 cava; Vr, right renal vein
 —(Moore).

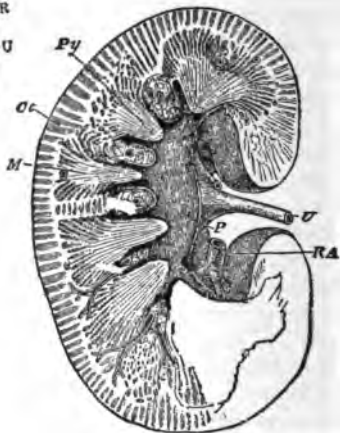


Fig. 19—KIDNEY
 Ct, cortical substance; M, me-
 dullary substance; Py, pyra-
 mids; P, pelvis of kidney;
 U, ureter; RA, renal artery—
 (Huxley).

thence propelled into the organs of the body. To these organs it supplies the nutriment with which it is charged; from them it takes their waste products, and, finally, returns by the veins to the heart, loaded with useless and injurious excretions, which sooner or later take the form of water, carbonic acid, and urea.

These excretory matters are separated from the blood by the excretory organs, of which there are three—the skin, the lungs and the kidneys.

Different as these organs may be in appearance, they are constructed upon one and the same principle. Each, in ultimate analysis, consists of a very thin sheet of tissue, like so much delicate blotting-paper, the one face of which is free, or lines a cavity in communication with the exterior of the body, while the other is in contact with the blood which has to be purified.

The excreted matters are, as it were, strained from the blood, through this delicate layer of tissue, and on to its free surface, whence they make their escape.

Each of these organs is especially concerned in the elimination of one of the chief waste products—water, carbonic acid and urea—tho it may at the same time be a means of escape for the others. Thus, the lungs are especially busied in getting rid of carbonic acid, but at the same time they give off a good deal of water. The duty of the kidneys is to excrete urea (together with other substances, chiefly salts), but at the same time they pass away a large quantity of water and a trifling amount of carbonic acid; while the skin gives off much water, some carbonic acid, and a certain quantity of saline matter, with a trace of urea.

Finally, the lungs play a double part, being not merely eliminators of waste, or excretory products, but importers into the economy of a substance which is not exactly either food or drink, but something as important as either—to wit, oxygen.

As the carbonic acid (and water) is passing from the blood through the lungs into the external air, oxygen is passing from the air through the lungs into the blood, and is immediately carried by the blood to all parts of the body. The waste which leaves the body contains more oxygen than the food which enters the body. Indeed oxidation, the oxygen being supplied by the blood, is going

on all over the body. All parts of the body are thus continually being oxidized, or, in other words, are continually burning, some more rapidly and fiercely than others. And this burning, tho it is carried on in a peculiar manner, so as never to give rise to a flame, yet nevertheless produces an amount of heat which is as efficient as a fire to raise the blood to a temperature of about 37° C. (98.6° F.); and this hot fluid, incessantly renewed in all parts of the body by the torrent of the circulation, warms the body, as a house is warmed by hot-water apparatus. Nor is it alone the heat of the body which is provided by this oxidation; the energy which appears in the muscular work done by the body has the same source. Just as the burning of the coal in a steam-engine supplies the motive power which drives the wheels, so, tho in a peculiar way, the oxidation of the muscles (and thus ultimately of the food) supplies the motive power of those muscular contractions which carry out the movements of the body. The food, like coal combustible or capable of oxidation, is built up into the living body, which, in like manner combustible, is continually being oxidized by the oxygen from the blood, thus doing work and giving out heat.

These alimentary, circulatory or distributive, excretory, and respiratory (oxidational) processes would, however, be worse than useless if they were not kept in strict proportion one to another. If the state of physiological balance is to be maintained, not only must the quantity of food taken be at least equivalent to the quantity of matter excreted; but that food must be distributed with due rapidity to the seat of each local waste. The circulatory system is the commissariat of the physiological army.

Again, if the body is to be maintained at a tolerably even temperature, while that of the air is constantly varying, the condition of the hot-water apparatus must be most carefully regulated.

"In other words," says Huxley, "a coördinating organ must be added to the organs mentioned, and this is found in

the nervous system, which not only possesses the function already described of enabling us to move our bodies and to know what is going on in the external world; but makes

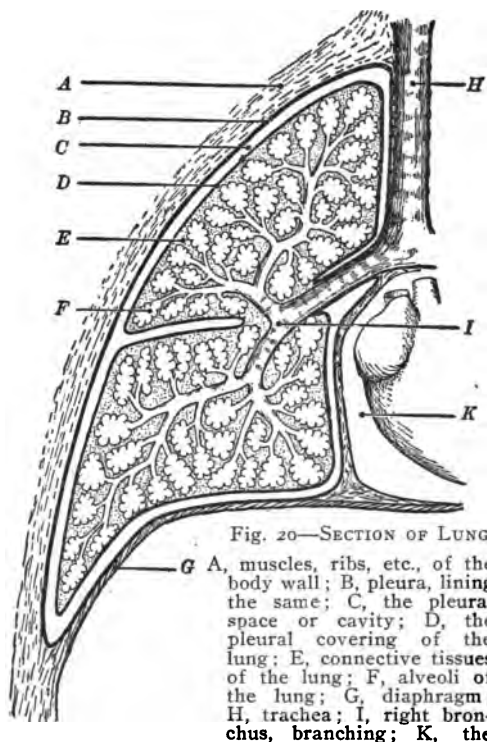


Fig. 20—SECTION OF LUNG

A, muscles, ribs, etc., of the body wall; B, pleura, lining the same; C, the pleural space or cavity; D, the pleural covering of the lung; E, connective tissues of the lung; F, alveoli of the lung; G, diaphragm; H, trachea; I, right bronchus, branching; K, the pericardial space in which lies the heart. Note the division of the lung into two lobes (Huxley).

us aware of the need of food, enables us to discriminate nutritious from innutritious matters, and to exert the muscular actions needful for seizing, killing and cooking; guides the hand to the mouth, governs all the movements

of the jaws and of the alimentary canal, and determines the due supply of the juices necessary for digestion.

"The various functions which have been thus briefly indicated constitute the greater part of what are called the vital actions of the human body, and so long as they are performed, the body is said to possess life. The cessation of the performance of these functions is what is ordinarily called death."

But there are really several kinds of death, which may, in the first place, be distinguished from one another under the two heads of local and of general death.

(i) Local death is going on at every moment, and in most, if not in all, parts of the living body. Individual cells of the epidermis and of the epithelium are incessantly dying and being cast off, to be replaced by others which are, as constantly, coming into separate existence. The like is true of blood-corpuscles, and probably of many other elements of the tissues.

This form of local death is usually insensible and is essential to the due maintenance of life. But, occasionally, local death occurs on a larger scale, as the result of injury, or as the consequence of disease. A burn, for example, may suddenly kill more or less of the skin; or part of the tissues of the skin may die, as in the case of the slough which lies in the midst of a boil; or a whole limb may die, and exhibit the strange phenomena of mortification.

The local death of some tissues is followed by their regeneration. Not only all the forms of epidermis and epithelium, but nerves, connective tissue, bone, and at any rate, some muscles, may be thus reproduced, even on a large scale.

(ii) General death is of two kinds, death of the body as a whole, and death of the tissues. By the former term is implied the absolute cessation of the functions of the brain, of the circulatory, and of the respiratory organs; by the latter, the entire disappearance of the vital actions

of the ultimate structural constituents of the body. When death takes place, the body, as a whole, dies first, the death of the tissues not occurring until after an interval, which is sometimes considerable.

Hence it is that, for some little time after what is ordinarily called death, the muscles of an executed criminal may be made to contract by the application of proper stimuli. The muscles are not dead, though the man is.

The modes in which death is brought about appear at first sight to be extremely varied. One speaks of natural death by old age, or by some of the endless forms of disease; of violent death by starvation, or by the innumerable varieties of injury, or poison. But, in reality, the immediate cause of death is always the stoppage of the functions of one of three organs: the cerebro-spinal nervous system, the lungs, or the heart. Thus, a man may be instantly killed by such an injury to a part of the brain which is called the spinal bulb or medulla oblongata as may be produced by hanging, or the breaking of the neck. Or death may be the immediate result of suffocation by strangulation, smothering or drowning—or, in other words, of stoppage of the respiratory functions. Or, finally, death ensues at once when the heart ceases to propel blood. These three organs—the brain, the lungs, and the heart—have been fancifully termed the tripod of life.

In ultimate analysis, however, life has but two legs to stand upon, the lungs and the heart, for death through the brain is always the effect of the secondary action of the injury to that organ upon the lungs or the heart. The functions of the brain cease when either respiration or circulation is at an end. But if circulation and respiration be kept up artificially, the brain may be removed without causing death. On the other hand, if the blood be not aerated, its circulation by the heart cannot preserve life; and, if the circulation be at an end, mere aeration of the blood in the lungs is equally ineffectual for the prevention of death.

With the cessation of life, the everyday forces of the inorganic world no longer remain the servants of the bodily frame, as they were during life, but become its masters. Oxygen, the slave of the living organism, becomes the lord of the dead body. Atom by atom, the complex molecules of the tissues are taken to pieces and reduced to simpler and more oxidized substances, until the soft parts are dissipated chiefly in the form of carbonic acid, ammonia, water and soluble salts, and the bones and teeth alone remain. But not even these dense and earthy structures are competent to offer a permanent resistance to water and air. Sooner or later the animal basis which holds together the earthy salts decomposes and dissolves—the solid structures become friable, and break down into powder. Finally, they dissolve and are diffused among the waters of the surface of the globe, just as the gaseous products of decomposition are dissipated through its atmosphere.

It is impossible to follow, with any degree of certainty, wanderings more varied and more extensive than those imagined by the ancient sages who held the doctrine of transmigration; but the chances are, that, sooner or later, some, if not all, of the scattered atoms will be gathered into new forms of life.

The sun's rays, acting through the vegetable world, build up some of the wandering molecules of carbonic acid, of water, of ammonia and of salts, into the fabric of plants. The plants are devoured by animals, animals devour one another, man devours both plants and other animals. Thus there is constant change of these elements from one living organism to another through all time and ages.

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